THE

NAVAL ARCHITECT'S AND SHIPBUILDER'S

POCKET-BOOK

THE

NAVAL ARCHITECT'S AND SHIPBUILDER'S

POCKET-BOOK

OF

Formulæ, Rules, and Tables

AND

MARINE ENGINEER'S AND SURVEYOR'S

HANDY BOOK OF REFERENCE

BY

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PREFACE

TO

THE EIGHTH EDITION

The rapid continued sale of successive editions has encouraged the Author to venture upon a thorough revision of the work for the present edition, and to take the opportunity of introducing in various sections the latest particulars of information and the latest and most approved data for working out the ever-varying problems with which the Naval Architect and Shipbuilder is daily confronted.

In the result, the Pocket-Book will be found now further enlarged by about fifty pages of additional matter of the first importance. A large number of new illustrations, also, specially drawn and engraved for the work, appear in the present edition.

As intimated in the Preface to the First Edition, the Author claims no originality for any of the material which he has endeavoured to collect and bring together in a concise and handy form, and where possible the sources of information have been indicated. He alone,

however, is responsible for the arrangement and correctness of the data and formulæ.

Those readers who are not already acquainted with recent editions of the work will find that especial attention has been given in successive revisions to the strength of materials, bending moments, and shearing forces of beams, with special regard to their application to the strength of vessels when at sea or in still water, and that the various new methods for determining the stability, speed, &c. of vessels have also been embodied in the work.

The subjects dealt with will be found grouped systematically under distinct headings, so as to facilitate reference apart from the index, and the various tables have been placed together at the end of the volume. As thus arranged and revised to date, it is hoped that the work will be found as complete and useful a POCKET-BOOK as could be desired, and will be appreciated not only by the Naval Architect and Engineer, but by every good Workman engaged in these professions.

The Author's thanks are again due and are cordially tendered to the numerous correspondents—many of them strangers to him—who have taken a generous interest in the work by offering suggestions and pointing out errors or omissions; and he trusts that the same kindly interest will continue to be taken.

WOODFORD: *July* 1, 1902.

PREFACE

TO

THE FIRST EDITION.

THE OBJECT of this work is to supply the great want which has long been experienced by nearly all who are connected professionally with shipbuilding, of a Pocket-Book which should contain all the ordinary Formulæ, Rules, and Tables required when working out necessary calculations, which up to the present time, as far as the Author is aware, have never been collected and put into so convenient a form, but have remained scattered through a number of large works, entailing, even in referring to the most commonly used Formulæ, much waste of time and trouble. An effort has here been made to gather all this valuable material, and to condense it into as compact a form as possible, so that the Naval Architect or the Shipbuilder may always have ready to his hand reliable data from which he can solve the numerous problems which daily come before him. How far this object has been attained may best be judged by those who have felt the need of such a work.

Several elementary subjects have been treated more fully than may seem consistent with the character of the book. This, however, has been done for the benefit of those who have received a practical rather than a theoretical training, and to whom such a book as this would be but of small service were they not first enabled to gather a few elementary principles, by which means they may learn to use and understand these Formulæ.

In justice to those authors whose works have been consulted, it must be added that most of the Rules and Formulæ here given are not original, although perhaps appearing in a new shape with a view to making them simpler.

There are many into whose hands this work will fall who are well able to criticise it, both as to the usefulness and the accuracy of the matter it contains. From such critics the Author invites any corrections or fresh material which may be useful for future editions.

SUMMARY OF CONTENTS.

MACKROW'S

POCKET BOOK

OF

FORMULÆ, RULES, AND TABLES

FOR

NAVAL ARCHITECTS AND SHIP-BUILDERS.

SIGNS AND SYMBOLS.

THE following are some of the signs and symbols commonly used in algebraical expressions:—

$=$ This is the sign of equality. It denotes that the quantities so connected are equal to one another; thus, 3 feet $=$ 1 yard.

$+$ This is the sign of addition, and signifies plus or more; thus, $4+3=7$.

$-$ This is the sign of subtraction, and signifies minus or less; thus, $4-3=1$.

$\times$ This is the sign of multiplication, and signifies multiplied by or into; thus, $4\times 3=12$.

$\div$ This is the sign of division, and signifies divided by; thus, $4\div 2=2$.

( ) { } [ ] These signs are called brackets, and denote that the quantities between them are to be treated as one quantity; thus, $5\{3(4+2)-6(3-2)\}=5(18-6)=60$.

—— This sign is called the bar or vinculum, and is sometimes used instead of the brackets; thus, $\overline{3(4+2)-6(3-2)}\times 5=60$.

Letters are often used to shorten or simplify a formula. Thus, supposing we wish to express length $\times$ breadth $\times$ depth, we might put the initial letters only, thus, $l\times b\times d$, or, as is usual when algebraical symbols are employed, leave out the sign $\times$ between the factors and write the formula $l.b.d.$

When it is wished to express division in a simple form the divisor is written under the dividend; thus, $(x+y)\div z=\frac{x+y}{z}$.

$:$, $::$, $:$, These are signs of proportion; the sign $:$ = is to, the sign $::$ = as; thus, $1:3::3:9$, 1 is to 3 as 3 is to 9.

$<$ This sign denotes less than; thus $2<4$ signifies 2 is less than 4.

$>$ This sign denotes more than; thus $4>2$ signifies 4 is more than 2.

$\because$ This sign signifies because.

$\therefore$ This sign signifies therefore. *Ex.*: $\because$ 9 is the square of 3 $\therefore$ 3 is the root of 9.

$\sim$ This sign denotes difference, and is placed between two quantities when it is not known which is the greater; thus $(x \sim y)$ signifies the difference between x and y.

$^\circ$, $'$, $''$ These signs are used to express certain angles in degrees, minutes, and seconds; thus 25 degrees 4 minutes 21 seconds would be expressed $25^\circ\ 4'\ 21''$.

Note.—The two latter signs are often used to express feet and inches; thus 2 feet 6 inches may be written $2'\ 6''$.

$\sqrt{\ }$ This sign is called the radical sign, and placed before a quantity indicates that some root of it is to be taken, and a small figure placed over the sign, called the exponent of the root, shows what root is to be extracted.

Thus $\sqrt[2]{a}$ or $\sqrt{a}$ means the square root of a.

$\sqrt[3]{a}$ „ cube „

$\sqrt[4]{a}$ „ fourth „

$\frac{\sqrt{a}}{b}$ This denotes that the square root of a has to be taken and divided by b.

$\frac{b}{\sqrt{a}}$ This denotes that b has to be divided by the square root of a.

$\sqrt{\frac{a+b}{a+d}}$ This denotes that the square root of $a+b$ has to be divided by the square root of $a+d$. It may also be written thus, $\sqrt{\frac{a+b}{a+d}}$, or $\frac{\sqrt{a+b}}{\sqrt{a+d}}$.

$\propto$ This is another sign of proportion. *Ex.*: $a \propto b$; that is, a varies as or is proportional to b.

∞ This sign expresses infinity; that is, it denotes a quantity greater than any finite quantity.

0 This sign denotes a quantity infinitely small, nought.

$\angle$ This sign denotes an angle. *Ex.*: $\angle ab$ would be written, the angle ab.

$\llcorner$ This sign denotes a right angle.

$\perp$ This sign denotes a perpendicular; as, $ab \perp cd$, i.e. ab is perpendicular to cd.

$\triangle$ This sign denotes a triangle; thus, $\triangle abc$, i.e. the triangle abc.

$\|$ This sign denotes parallel to. *Ex.*: $ab \| cd$ would be written, ab is parallel to cd.

f or F These express a function; as, $a = fx$; that is, a is a function of x or equals x.

$\int$ This is the sign of integration; that is, it indicates that the expression before which it is placed is to be integrated. When the expression has to be integrated twice or three times the sign is repeated (thus, $\int\int$, $\int\int\int$); but if more than three times an index is placed above it (thus, $\int^n$).

D or d These are the signs of differentiation; an index placed above the sign (thus, d^2) indicates the result of the repetition of the process denoted by that sign.

Σ This sign (the Greek letter sigma) is used to denote that the algebraical sum of a quantity is to be taken. It is commonly used to indicate the sum of finite differences, in nearly the same manner as the symbol $\int$.

$\boxed{C}$ This sign is sometimes used instead of π, being a modification of the letter C, for circumference.

$\boxed{B}$ This sign is sometimes used instead of ϵ, being a modification of the letter B, for base.

g This sign is used to denote the force of gravity at any given latitude.

π The Greek letter pi is invariably used to denote 3·14159; that is, the ratio borne by the diameter of a circle to its circumference.

e or ϵ This letter is generally used to denote 2·71828, which is the base of hyperbolic or Napierian logarithms.

As the letters of the Greek alphabet are of constant recurrence in mathematical formulæ it has been deemed advisable to append the following table:—

Α α	Alpha.	Ι ι	Iota.	Ρ ρ	Rho.
Β β	Beta.	Κ κ	Kappa.	Σ σ ς	Sigma.
Γ γ	Gamma.	Λ λ	Lambda.	Τ τ	Tau.
Δ δ	Delta.	Μ μ	Mu.	Υ υ	Upsilon.
Ε ε	Epsilon.	Ν ν	Nu.	Φ φ	Phi.
Ζ ζ	Zeta.	Ξ ξ	Xi.	Χ χ	Chi.
Η η	Eta.	Ο ο	Omicron.	Ψ ψ	Psi.
Θ θ	Theta.	Π π	Pi.	Ω ω	Omega.

DECIMAL FRACTIONS.

Decimal Fractions are those which have 10, 100, 1000, &c., for a denominator, and are expressed by writing the numerator only and placing a point before it on the left hand.

Ex. 1. $\frac{1}{10} = \cdot 1.$ $\frac{76}{100} = \cdot 76.$ $\frac{876}{1000} = \cdot 876.$

Ex. 2. $\frac{3}{10} = \cdot 3.$ $\frac{3}{100} = \cdot 03.$ $\frac{3}{1000} = \cdot 003.$

Ex. 3. $113\cdot 3 = 113\frac{3}{10} = \frac{1133}{10} = \frac{11330}{100}.$

Ex. 4. $113\cdot 03 = \frac{113\cdot 03}{1} = \frac{1130\cdot 3}{10} = \frac{11303}{100}.$

ADDITION OF DECIMALS.

RULE.—Arrange the numbers so that all the decimal points come directly under one another; add them together as in whole numbers, and point off as many figures for decimals as are equal to the greatest number of decimals in any of the given numbers.

Ex.: Add together 3·79, ·117, 87·225, 478·91.

$$\begin{array}{r} 3\cdot 79 \\ \cdot 117 \\ 87\cdot 225 \\ 478\cdot 91 \\ \hline 570\cdot 042 \end{array} \quad \textit{Ans.}$$

SUBTRACTION OF DECIMALS.

RULE.—Place the numbers under one another, as in addition; subtract as in whole numbers, keeping the decimal point in the remainder directly under those above it.

$$\begin{array}{rr} \textit{Ex.}\text{: From} & 97\cdot 378 \\ \text{take} & 46\cdot 4972 \\ \hline & 50\cdot 8808 \end{array} \quad \textit{Ans.}$$

MULTIPLICATION OF DECIMALS.

RULE.—Multiply the factors together, as in whole numbers; then point off from the product as many decimal places as there are in both factors, supplying any deficiency by annexing ciphers to the left hand.

$$\begin{array}{rr} \textit{Ex. } 1.\ \text{Mult.} & 4\cdot 735 \\ \text{by} & \cdot 374 \\ \hline & 18940 \\ & 33145 \\ & 14205 \\ \hline & 1\cdot 770890 \end{array} \quad \textit{Ans.} \qquad \begin{array}{rr} \textit{Ex. } 2.\ \text{Mult.} & \cdot 04735 \\ \text{by} & \cdot 0374 \\ \hline & 18940 \\ & 33145 \\ & 14205 \\ \hline & \cdot 001770890 \end{array} \quad \textit{Ans.}$$

DIVISION OF DECIMALS.

RULE.—Remove the decimal point in the dividend as many places to the right as there are decimal places in the divisor; supply any deficiency by annexing ciphers. Then make the divisor a whole number, and proceed as in the division of simple numbers, and the quotient will contain as many decimal places as are *used* in the dividend.

Ex. 1. Divide 74·23973 by 6·12.

```
612) 7423·973 (12·130. Ans.
     612
     1303
     1224
      799
      612
      1877
      1836
       413
```

Ex. 2. Divide ·7423973 by 612.

```
612) ·7423973 (·0012130. Ans.
      612
      1303
      1224
       799
       612
       1877
       1836
        413
```

TO REDUCE ANY FRACTION TO A DECIMAL.

RULE.—Annex ciphers to the numerator till it be equal to or greater than the denominator; divide by the denominator, as in division of decimals, and the quotient will be the decimal required.

Ex. 1. Reduce $\frac{7}{256}$ to a decimal.

```
256) 7·00000000 (·02734375. Ans.
     512
     1880
     1792
      880
      768
      1120
      1024
        960
        768
        1920
        1792
         1280
         1280
```

Ex. 2. Reduce $\frac{7}{12}$ to a decimal.

```
12) 7·00000000
    ·58333333. Ans.
```

TO REDUCE NUMBERS OF DIFFERENT DENOMINATIONS INTO DECIMALS.

RULE 1.—Reduce the given weight or measure, &c., into the lowest denomination given, for a dividend; then reduce the

integer into the same denomination for a divisor; the resulting fraction, changed to a decimal, will be the decimal required.

RULE 2.—Divide the least denomination by such a number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same denomination; then divide by such a number as will reduce it to the next greater; thus proceed till it be reduced to the decimal of the required integer.

Ex. 1 to RULE 1.—Reduce 2 cwt. 3 qrs. 21 lbs. to the decimal of a ton.

$$\frac{\text{2 cwt. 3 qrs. 21 lbs.}}{\text{1 ton}} = \frac{\text{329 lbs.}}{\text{2240 lbs.}} = \cdot146875 \text{ ton};$$

or, by RULE 2—

$$\begin{array}{rl} 28\left\{\begin{array}{r} 7) \\ 4) \end{array}\right. & \begin{array}{l} \underline{21\cdot0 \text{ lbs.}} \\ \underline{\;\;3\cdot0} \end{array} \\ 4) & \underline{\;\;3\cdot75 \text{ qrs.}} \\ 20) & \underline{\;\;2\cdot9375 \text{ cwts.}} \\ \textit{Ans.} & \underline{\cdot146875} \text{ ton.} \end{array}$$

Ex. 2 to RULE 1.—Reduce 2 ft. 9 in. to the decimal of a yard.

$$\frac{\text{2 ft. 9 in.}}{\text{1 yard}} = \frac{\text{33 in.}}{\text{36 in.}} = \cdot916666 \text{ yard};$$

or, by RULE 2—

$$\begin{array}{rl} 12) & \underline{9 \text{ in.}} \\ 3) & \underline{2\cdot75 \text{ feet}} \\ \textit{Ans.} & \underline{\cdot91666} \text{ yard.} \end{array}$$

TO FIND THE VALUE OF ANY DECIMAL.

RULE.—Multiply the given decimal by the number of parts contained in the next lesser denomination, and point off from the product as many figures as the decimal consists of. Multiply the remaining decimal by the number of parts in the next lesser denomination, and point off as many decimals in the product as before. Proceed thus till you have brought out the least known parts of the integer.

Ex. 1. What is the value of ·146875 of a ton?

$$\begin{array}{rr} & \cdot146875 \\ & \underline{20} \\ \text{cwts.} & \underline{2\cdot937500} \\ & 4 \\ \text{qrs.} & \underline{3\cdot750000} \\ & \underline{28} \\ \text{lbs.} & \underline{21\cdot0000000} \end{array}$$

Ans. = 2 cwts. 3 qrs. 21 lbs.

Ex. 2. What is the value of ·91666 of a yard?

$$\begin{array}{rr} & \cdot91666 \\ & \underline{3} \\ \text{feet} & 2\cdot74998 \\ & \underline{12} \\ \text{in.} & \underline{8\cdot99976} \end{array}$$

Ans. = 2 ft. 9 in.

EVOLUTION.

TO EXTRACT THE SQUARE ROOT.

RULE.—If there be decimals in the given number, make them to consist of two, four, six, &c., places by annexing ciphers to the right hand; then separate the whole into periods of two figures each, beginning at the right hand, and the left-hand period will consist of one or two figures, according as the number of figures in the whole number is odd or even. Find a square number equal to or the next less than the left-hand period, and put the root of it in the quotient; subtract this square from the left-hand period, and to the remainder bring down the next period for a dividend, and to the left hand of it write double the quotient for a divisor; then consider what figure if annexed to the divisor and the result multiplied by it the product may be equal to or the next less number than the dividend, and it will be the second figure of the root. From the dividend subtract the product, and to the remainder bring down the next period for a new dividend; double the figures in the quotient for a divisor, and continue the operation as above till all the periods are used.

Example 1.

Extract the sq. root of 10291264.

	10291264	3208. *Ans.*
	9	
62	129	
20	124	
6408	51264	
	51264	

Example 2.

Extract the sq. root of 177746·56.

	177746·56	421·6. *Ans.*
	16	
82	177	
2	164	
841	1346	
1	841	
8426	50556	
	50556	

TO EXTRACT THE SQUARE ROOT OF A VULGAR FRACTION.

RULE 1.—Multiply the numerator by the denominator, and extract the square root of the product; the numerator of the given fraction, written above this root, or the denominator written below it, will express the root of any fraction when reduced to its lowest terms

That is—

$$\sqrt{\frac{a}{b}} = \frac{\sqrt{a}}{\sqrt{b}} = \frac{\sqrt{ab}}{b} = \frac{a}{\sqrt{ab}} = \frac{1}{b}\sqrt{(ab)}.$$

RULE 2.—Reduce the given fraction to its lowest terms; then extract the square root of the numerator for a new numerator,

and the square root of the denominator for a new denominator. If the fraction will not extract even, reduce it to a decimal and then extract the square root.

To Extract the Cube Root.

Rule.—If there be decimals in the given number, make them to consist of three, six, nine, &c., places by annexing ciphers to the right hand, if necessary; then separate the whole into periods of three figures each, beginning at the right hand. The left-hand period may consist of one, two, or three figures. Find the nearest cube to the first period, subtract it therefrom, and put the root in the quotient; then thrice the square of this root will be the trial divisor for finding the next figure. Multiply the root figure, or figures already found, by three, and prefix the product to the next new root-figure (which will be seen by the trial divisor); then multiply this number by the aforesaid new root-figure, and place the product two figures to the right below the trial divisor, and add it to the trial divisor: this sum will be the true divisor. Under this divisor write the square of the last root-figure, which add to the two sums above, and the result is the next trial divisor; the true divisor being found as before directed.

Example.

Extract the cube root of 4088324799.

		4088324799	1599. *Ans.*
True divisor 1^3 =		1	
Trial divisor $1^2 \times 3 = 3$		3088	
$35 \times 5 = 175$			
True divisor	475×5	2375	
5^2 =	25	713324	
Trial divisor	675		
$459 \times 9 =$	4131		
	71631×9	644679	
9^2 =	81	68645799	
Trial divisor	= 75843		
$4779 \times 9 =$	43011		
True divisor	= 7627311×9	68645799	

To Extract any Root whatever.

If N be any given number whatever whose root is sought, n the index of the power, r the nearest rational root; or r^n the nearest rational power to N, whether greater or less, and R = the root sought: then—

$$R = \frac{\{N \times (n+1)\} + \{(n-1) \times r^n\}}{\{N \times (n-1)\} + \{(n+1) \times r^n\}} \times r.$$

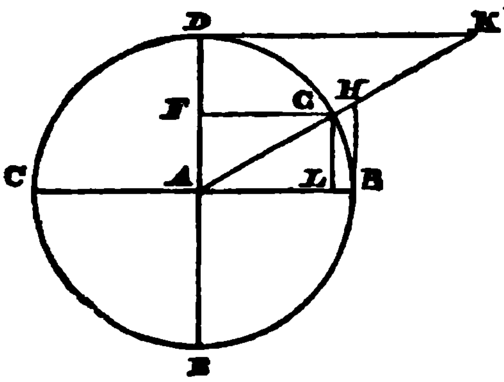
TRIGONOMETRY.

THE *complement* of an angle is its defect from a right angle; thus if A denote the number of degrees contained in any angle, $90° - A$ is the number of degrees contained in the complement of that angle.

The *supplement* of an angle is its defect from two right angles; thus $180° - A$ is the number of degrees contained in the supplement of that angle.

TRIGONOMETRICAL RATIOS.

FIG. 1.



All the different functions of an angle, or of the arc subtending that angle, are expressed in a ratio to the radius of the circle which describes the arc. Thus in fig. 1—

$$\text{sine } A = GL = \frac{GL}{1} = \frac{GL}{GA} = \frac{AD}{AK} = \frac{1}{\text{cosec } A}$$

$$\text{co-sine } A = FG = \frac{AL}{1} = \frac{AL}{AG} = \frac{AB}{AH} = \frac{1}{\sec A}$$

$$\text{tangent } A = HB = \frac{HB}{1} = \frac{HB}{AB} = \frac{AD}{DK} = \frac{1}{\text{cotan } A}$$

$$\text{co-tangent } A = DK = \frac{DK}{1} = \frac{DK}{DA} = \frac{AB}{HB} = \frac{1}{\tan A}$$

$$\text{secant } A = AH = \frac{AH}{1} = \frac{AH}{AB} = \frac{AG}{AL} = \frac{1}{\cos A}$$

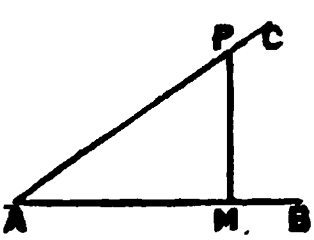
$$\text{co-secant } A = AK = \frac{AK}{1} = \frac{AK}{AD} = \frac{AG}{LG} = \frac{1}{\sin A}$$

$$\text{versed sine } A = LB = AB - AL = 1 - \cos A$$

$$\text{co-versed sine } A = FD = AD - GL = 1 - \sin A.$$

Note.—The lines dropped upon the radii are perpendicular to those radii.

FIG. 2.



It is more convenient to define the sine, co-sine, &c., as follows:—Let BAC (fig. 2) be any angle; take any point in either of the containing sides and from it draw a perpendicular to the other side; let P be the point in the side AC, and PM perpendicular to AB; let A denote the angle BAC. Then—

$$\text{sine A} = \frac{\text{perpendicular}}{\text{hypotenuse}} = \frac{\text{PM}}{\text{AP}}$$

$$\text{co-sine A} = \frac{\text{base}}{\text{hypotenuse}} = \frac{\text{AM}}{\text{AP}}$$

$$\text{tangent A} = \frac{\text{perpendicular}}{\text{base}} = \frac{\text{PM}}{\text{AM}}$$

$$\text{co-tangent A} = \frac{\text{base}}{\text{perpendicular}} = \frac{\text{AM}}{\text{PM}}$$

$$\text{secant A} = \frac{\text{hypotenuse}}{\text{base}} = \frac{\text{AP}}{\text{AM}}$$

$$\text{co-secant A} = \frac{\text{hypotenuse}}{\text{perpendicular}} = \frac{\text{AP}}{\text{PM}}$$

$$\text{versed sine A} = 1 - \cos \text{A}$$

$$\text{co-versed sine A} = 1 - \sin \text{A}.$$

MEASUREMENT OF ANGLES.

There are three modes of measuring angles, viz.—

1st. The sexagesimal or English method.
2nd. The centesimal or French method.
3rd. The circular measure.

The sexagesimal method and the circular measure only will be treated of here.

The Sexagesimal Method.—In this method a right angle is supposed to be divided into 90 equal parts, each of which parts is termed a degree; each degree is divided into 60 equal parts, called minutes, and each minute is divided into 60 equal parts, called seconds.

To express the measure of an angle in degrees and decimal parts of a degree.

Ex.: To bring 24° 16′ 15″ into the decimal of a degree.

60) 15 second
·25 of a minute
60) 16·25 minutes
·2708 of a degree.
Answer: 24·2708 degrees.

THE CIRCULAR MEASURE.

1st. The unit of circular measure is an angle which is subtended at the centre of a circle by an arc equal to the radius of that circle. It is called a radian. Such an angle is equal to

$$\frac{2 \text{ right angles}}{\pi} = \frac{180°}{3{\cdot}14159} = 57°{\cdot}2958, \text{ nearly}.$$

2nd. The circular measure of an angle is equal to a fraction

which has for its numerator the arc subtended by that angle at the centre of any circle, and for its denominator the radius of that circle.

Since the circumference of any circle is 2π times the radius, four right angles are equal to 2π radians. Consequently one right angle is equal to $\frac{\pi}{2}$ radians.

Approximate values of π are 3·14159 and $\frac{22}{7}$.

To find the circular measure of any angle expressed in degrees, minutes, and seconds.

RULE.—Multiply the measure of the angle in degrees by π, and divide by 180.

Ex.: Express $12° 5' 4'' = 43504''$ in circular measure.

$$\frac{(12° 5' 4'') \times \pi}{180} = \frac{43504 \times \pi}{180 \times 60 \times 60} = \frac{2719 \times \pi}{40500} \textit{ Answer.}$$

To find the measure of any angle in degrees, minutes, and seconds, the circular measure being given.

RULE.—Multiply the circular measure of the angle by 180, and divide by π.

Ex. 1. Express in degrees, &c., an angle the circular measure of which is $\frac{2\pi}{3}$.

$$\frac{2\pi \times 180}{3 \times \pi} = 120°.$$

GENERAL FORMULÆ.

$$\sin^2 \theta + \cos^2 \theta = 1. \qquad \sec^2 \theta = 1 + \tan^2 \theta.$$

$$\operatorname{cosec}^2 \theta = 1 + \cot^2 \theta.$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B.$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B.$$

$$\sin(A-B) = \sin A \cos B - \cos A \sin B.$$

$$\cos(A-B) = \cos A \cos B + \sin A \sin B.$$

$$\sin A + \sin B = 2 \sin \frac{A+B}{2} \cos \frac{A-B}{2}.$$

$$\cos A + \cos B = 2 \cos \frac{A+B}{2} \cos \frac{A-B}{2}.$$

$$\sin A - \sin B = 2 \cos \frac{A+B}{2} \sin \frac{A-B}{2}.$$

$$\cos B - \cos A = 2 \sin \frac{A+B}{2} \sin \frac{A-B}{2}.$$

$$\tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A \tan B}.$$

$$\tan(A-B) = \frac{\tan A - \tan B}{1 + \tan A \tan B}.$$

$\sin 2A = 2 \sin A \cos A.$ $\quad\quad \sin 3A = 3 \sin A - 4 \sin^3 A.$

$\cos 2A = \cos^2 A - \sin^2 A.$ $\quad\quad \cos 3A = 4 \cos^3 A - 3 \cos A.$

$$\sin \frac{A}{2} = \pm \sqrt{\frac{1 - \cos A}{2}}. \qquad \cos \frac{A}{2} = \pm \sqrt{\frac{1 + \cos A}{2}}.$$

And when A, B, C are the three angles of a triangle,

$$A + B + C = \pi \text{ radians or two right angles;}$$

and $\quad \sin (A + B) = \sin (\pi - C) = \sin C.$

When A is any angle,

$\sin (-A) = -\sin A.$ $\quad \cos (-A) = \cos A.$ $\quad \tan (-A) = -\tan A.$

$\sin (90° - A) = \cos A.$ $\quad \cos (90° - A) = \sin A.$ $\quad \tan (90° - A) = \cot A.$

$\sin (90° + A) = \cos A.$ $\quad \cos (90° + A) = -\sin A.$ $\quad \tan (90° + A) = -\cot A.$

$\sin (180° - A) = \sin A.$ $\quad \cos (180° - A) = -\cos A.$ $\quad \tan (180° - A) = -\tan A.$

$\sin (180° + A) = -\sin A.$ $\quad \cos (180° + A) = -\cos A.$ $\quad \tan (180° + A) = \tan A.$

Inverse Functions.

If $\sin \alpha = x$, then $\alpha = \sin^{-1} x$.
If $\cos \alpha = y$, then $\alpha = \cos^{-1} y$.
And so on.

Note.—

$\sin^{-1} x$ is read 'inverse sine x,' &c.

Properties of Triangles.

Fig. 3.

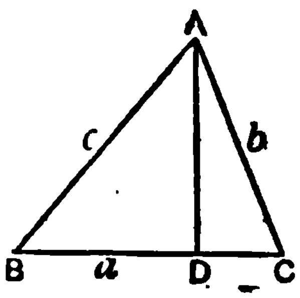


Fig. 4.

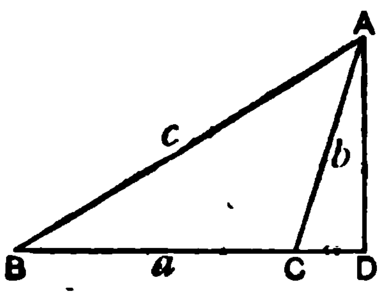
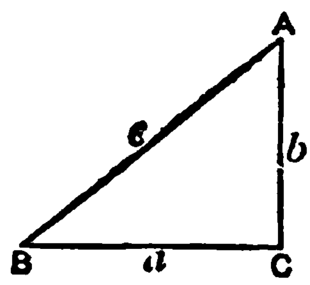


Fig. 5.



Note.—The sides opposite the angles A, B, C respectively will be denoted by the letters a, b, c. The angle BDA in figs. 3 and 4 is supposed to be a right angle.

In fig. 3, where B and C are acute angles, we have—

$$\sin B = \frac{AD}{AB} = \frac{AD}{c}$$

$$\sin C = \frac{AD}{AC} = \frac{AD}{b}$$

$$\therefore \frac{\sin B}{\sin C} = \frac{AD}{c} \div \frac{AD}{b} = \frac{b}{c}.$$

In fig. 4, where C is an obtuse angle, and in fig. 5, where C is a right angle, the proof is similar.

And therefore in any triangle $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$.

Also $$\cos A = \frac{b^2 + c^2 - a^2}{2bc}.$$

$$\sin \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}; \quad \cos \frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

$$\tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}; \quad \sin A = \frac{2}{bc}\sqrt{s(s-a)(s-b)(s-c)}$$

where $2s = a + b + c$.

$$a = b \cos C + c \cos B; \qquad \tan \frac{B-C}{2} = \frac{b-c}{b+c} \cot \frac{A}{2}.$$

SOLUTION OF TRIANGLES.

Every triangle has six elements—three sides and three angles. If any three of these be given (provided they be not the three angles) the triangle can be completely determined.

RIGHT-ANGLED TRIANGLES.

Let C be the right angle, and therefore c the hypothenuse.

(i.) Given hypothenuse (c) and one side (a).

$$b = \sqrt{c^2 - a^2}, \tan B = \frac{b}{a}, \text{ and } A = 90° - B.$$

(ii.) Given the two sides (a and b).

$$c = \sqrt{a^2 + b^2}, \tan B = \frac{b}{a}, \text{ and } A = 90° - B.$$

(iii.) Given an angle (B) and one of the sides (a).

$$b = a \tan B, \ c = a \sec B.$$

(iv.) Given an angle (B) and the hypothenuse (c).

$$a = c \cos B, \ b = c \sin B, \ A = 90° - B.$$

ANY TRIANGLES.

(i.) Given the three sides, a, b, and c.

$$\tan \frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}, \ \tan \frac{B}{2} = \sqrt{\frac{(s-c)(s-a)}{s(s-b)}},$$

$$C = 180° - A - B,$$

where $$2s = a + b + c.$$

(ii.) Given two sides, b and c, and the included angle A.

$$\tan\frac{B-C}{2}=\frac{b-c}{b+c}\cot\frac{A}{2}. \qquad \frac{B+C}{2}=90^\circ-\frac{A}{2}.$$

From $\frac{B-C}{2}$ and $\frac{B+C}{2}$ we can get B and C; and $a=b\,\frac{\sin A}{\sin B}$.

(iii.) Given two sides, b and c, and the angle B opposite to one of them.

$\sin C=\frac{c}{b}\sin B$. We thus obtain C; and $A=(180-B-C)$.

Also $$a=b\,\frac{\sin A}{\sin B}.$$

As there are generally two angles between 0° and 180° whose sine is $\frac{c}{b}\sin B$, two values of C are often admissible, and sometimes two triangles can be constructed.

(iv.) Given one side and two angles, a, B, and C.

$$A=180^\circ-B-C;\ b=a\,\frac{\sin B}{\sin A};\ c=a\,\frac{\sin C}{\sin A}.$$

(v.) When the three angles only are given, the absolute magnitude of the sides cannot be determined, but their ratios are given by $\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}$.

Expressions for the Area of Triangles.

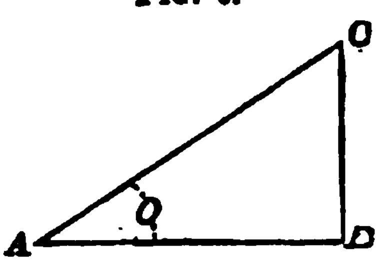
I. $$\text{Area}=\tfrac{1}{2}ac\sin B$$

II. $$\text{Area}=\sqrt{s(s-a)(s-b)(s-c)},$$

where $$2s=a+b+c.$$

Measurement of Heights and Distances.

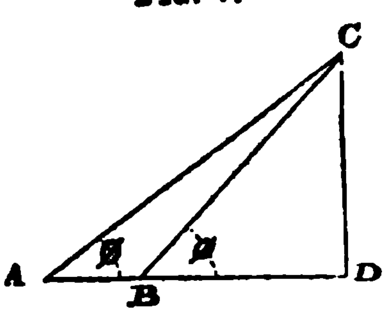
Fig. 6.



1. *To find the height of an accessible object.* (Fig. 6.)

Let BC be the object and AB a line measured horizontally, $a=AB$, and $\theta=$ the angle of elevation, then $BC=a\tan\theta=$ height required.

Fig. 7.



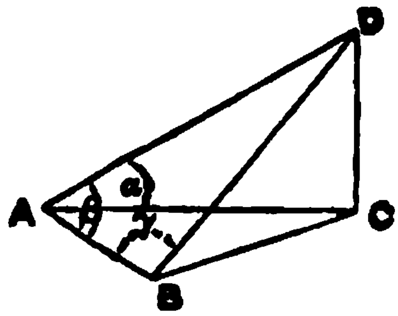
2. *To find the height of an inaccessible object on a horizontal plane.* (Fig. 7.)

Measure a convenient distance AB in the straight line BD, produced, and let $a=AB$; then

$$CD=a\left(\frac{\sin\theta\sin\phi}{\sin(\theta-\phi)}\right).$$

3. *To find the height of an inaccessible object when it is not convenient to measure any distance in a line with the base of the object.* (Fig. 8.)

FIG. 8.

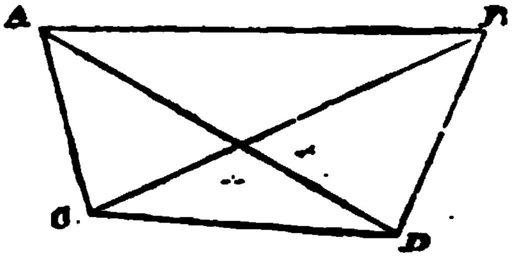


Measure the length AB in any direction from A; at A observe the angles DAC and DAB, and at B observe the angle DBA; then

$$DC = AB\,\frac{\sin\alpha.\sin\gamma}{\sin(\beta+\gamma)}.$$

4. *To find the distance between two visible but inaccessible objects.* (Fig. 9.)

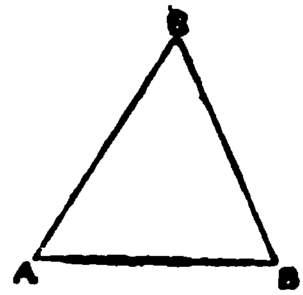
FIG. 9.



Let A and B be the objects; measure a line CD, and suppose A,B,C,D to be in one plane; then observe the angles ACD and ADC, and AC can be found; again observe the angles BCD and BDC, from which BC can be found: thus knowing AC and BC, and the included angle ACB, AB can be determined.

5. *To find the distance of a ship from the shore.* (Fig. 10.)

FIG. 10.

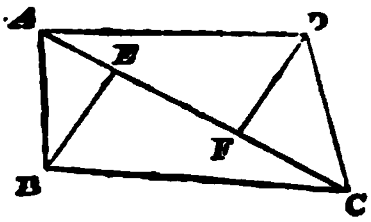


Let S be the position of the ship; measure AB, a straight line between two points on the shore; then

$$AS = AB\,.\,\frac{\sin SBA}{\sin(SAB + SBA)}.$$

AREAS OF TRIANGLES, POLYGONS, AND CIRCLES.

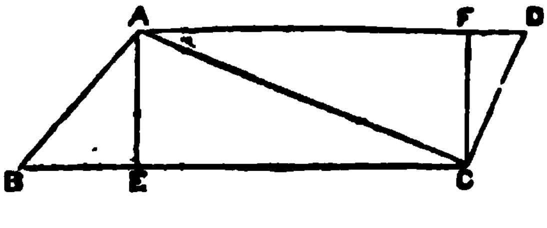
FIG. 11.



1. *The area of any quadrilateral figure.* ABCD (fig. 11),

equals $\frac{1}{2}$AC (BE + DF).

FIG. 12.



2. *The area of any quadrilateral figure* (fig. 12), ABCD, *two of whose sides*, AD *and* BC, *are parallel*,

equals $\frac{1}{2}$(BC + AD)AE, or

$\frac{1}{2}$(sum of parallel sides) × (perpendicular distance between them).

3. *The area of any quadrilateral figure*, ABCF (fig. 12),

equals $\frac{1}{2}$(BC × AE) + $\frac{1}{2}$(CE × FC).

4. *The area of any triangle*, ABC (figs. 13 and 14),

FIG. 13.

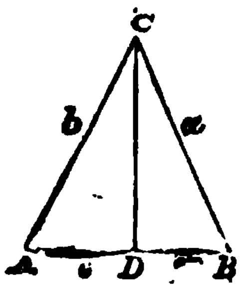
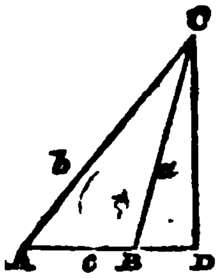


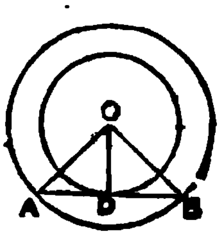
FIG. 14.



equals $\frac{1}{2}$ AB . CD $= \frac{1}{2}$AB . AC . sin A $= \frac{1}{2}c \cdot b \cdot \sin A$.

5. *To find the radii of the inscribed and circumscribed circles of a regular polygon.* (Fig. 15.)

FIG. 15.



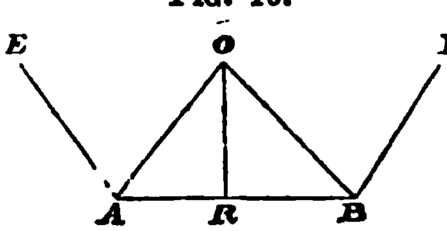
Let AB be the side of a regular polygon of n sides; let O be the centre of the circles, OD the radius of the inscribed and OA the radius of the circumscribed circle.

Let AB $= a$, AO $=$ R, OD $= r$, then

$$R = \frac{a}{2 \sin \frac{\pi}{n}}, \qquad r = \frac{a}{2 \tan \frac{\pi}{n}}.$$

6. *To find the area of a regular polygon in terms of its sides.* (Fig. 16.)

FIG. 16.

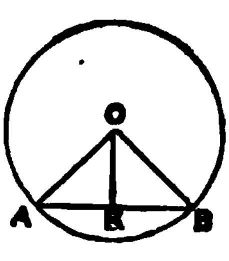


Let EA, AB, BF be three consecutive sides of a regular polygon of n sides, and let each side $= a$.

Bisect the angles EAB and ABF by the lines OA, OB, meeting in O. Draw OR at right angles to AB.

Then area of polygon $= \frac{na^2}{4} \cdot \cot \frac{\pi}{n}$.

FIG 17.

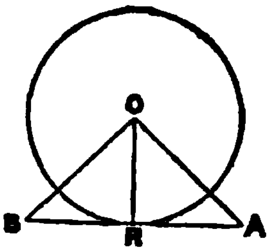


7. *To find the area of a regular polygon inscribed in a circle.* (Fig. 17.)

Let O be the centre of the circle, r the radius, and AB a side of the polygon.

Then area of polygon $= \frac{nr^2}{2} \cdot \sin \frac{2\pi}{n}$.

FIG. 18.



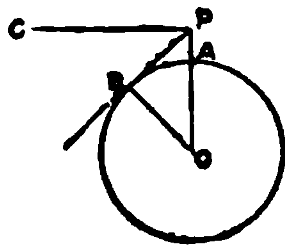
8. *To find the area of a regular polygon described about a circle.* (Fig. 18.)

Let O be the centre of the circle, r the radius, and AB a side of the polygon.

Then area of polygon $= nr^2 \cdot \tan \frac{\pi}{n}$.

9. *To find the dip of the horizon.* (Fig. 19.) Let O denote the centre of the earth, PB a tangent from the eye of an observer looking from a height AP to the earth's surface at B; then B is a point on the horizon; draw PC at right angles to PO; then the angle BPC is called the dip of the horizon.

FIG. 19.



Let OP cut the earth's surface at A, and let the angle BPC be denoted by θ; then $PB = \sqrt{AP(2AO + AP)} = \sqrt{2AP\ AO}$ approximately, as AO is very great compared with AP.

Let AP $= h$ miles and AO $= 4000$ miles, then PB $= \sqrt{8000h}$ and $\tan\theta = \sqrt{\dfrac{2h}{4000}}$ radians.

Then $\theta = \sqrt{\dfrac{2h}{4000}}$ radians approximately.

Then θ in degrees $= \dfrac{180}{\pi}.\ \sqrt{\dfrac{2h}{4000}}.$

TABLE GIVING THE SIGNS AND VALUES OF THE TRIGONOMETRICAL RATIOS FOR CERTAIN ANGLES.

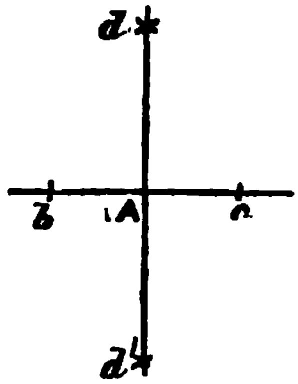
Ratios	0°	Signs	30°	Signs	45°	Signs	60°	Signs	90°	Signs	120°
Sine	0	+	$\frac{1}{2}$	+	$\frac{1}{\sqrt{2}}$	+	$\frac{\sqrt{3}}{2}$	+	1	+	$\frac{\sqrt{3}}{2}$
Co sine	1	+	$\frac{\sqrt{3}}{2}$	+	$\frac{1}{\sqrt{2}}$	+	$\frac{1}{2}$	+	0	−	$\frac{1}{2}$
Tangent	0	+	$\frac{1}{\sqrt{3}}$	+	1	+	$\sqrt{3}$	+	∞	−	$\sqrt{3}$
Co-tangent	∞	+	$\sqrt{3}$	+	1	+	$\frac{1}{\sqrt{3}}$	+	0	−	$\frac{1}{\sqrt{3}}$
Secant	1	+	$\frac{2}{\sqrt{3}}$	+	$\sqrt{2}$	+	2	+	∞	−	2
Co-secant	∞	+	2	+	$\sqrt{2}$	+	$\frac{2}{\sqrt{3}}$	+	1	+	$\frac{2}{\sqrt{3}}$

Ratios	Signs	135°	Signs	150°	Signs	180°	Signs	270°	Signs	360°
Sine	+	$\frac{1}{\sqrt{2}}$	+	$\frac{1}{2}$	+	0	−	1	−	0
Co-sine	−	$\frac{1}{\sqrt{2}}$	−	$\frac{\sqrt{3}}{2}$	−	1	−	0	+	1
Tangent	−	1	−	$\frac{1}{\sqrt{3}}$	+	0	+	∞	−	0
Co-tangent	−	1	−	$\sqrt{3}$	+	∞	+	0	−	∞
Secant	−	$\sqrt{2}$	−	$\frac{2}{\sqrt{3}}$	−	1	−	∞	+	1
Co-secant	+	$\sqrt{2}$	+	2	+	∞	−	1	−	∞

PRACTICAL GEOMETRY.

1. *From any given point in a straight line to erect a perpendicular.* (Fig. 20.)

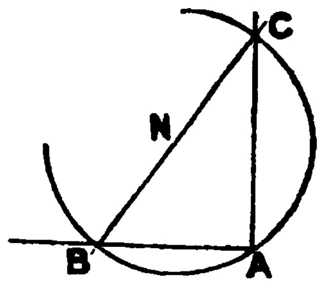
Fig. 20.



On each side of the point A in the line from which the perpendicular is to be erected set off equal distances A*b*, A*c*; and from *b* and *c* as centres, with any radius greater than A*b* or A*c*, describe arcs cutting each other at *d*, *d'*; a line drawn through *dd'* will pass through the point A, and A*d* will be perpendicular to *bc*.

2. *To erect a perpendicular at or near the end of a line.* (Fig. 21.)

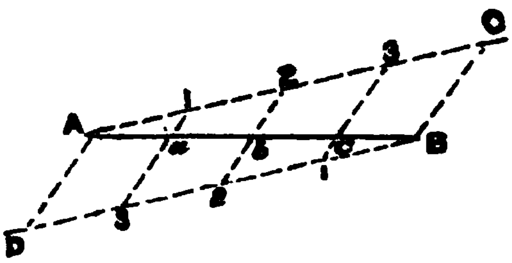
Fig. 21.



With any convenient radius, and at any distance from the given line AB, describe an arc, as BAC, cutting the given point in A; through the centre of the circle N draw the line BNC: a line drawn from the point A, cutting the intersection at C, will be the required perpendicular.

3. *To divide a line into any number of equal parts.* (Fig. 22.)

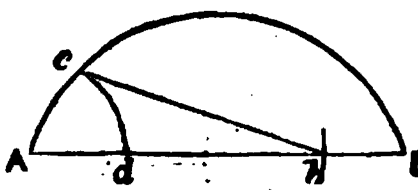
Fig. 22.



Let AB be the given straight line to be divided into a number of equal parts; through the points A and B draw two parallel lines AC and DB, forming any convenient angle with AB; upon AC and DB set off the number of equal parts required, as A–1, 1–2, &c., B–1, 1–2, &c; join A and D, 1 and 3, 2 and 2, 3 and 1, C and B, cutting AB in *a*, *b*, and *c*, which will thus be divided into four equal parts.

4. *To find the length of any given arc of a circle.* (Fig. 23.)

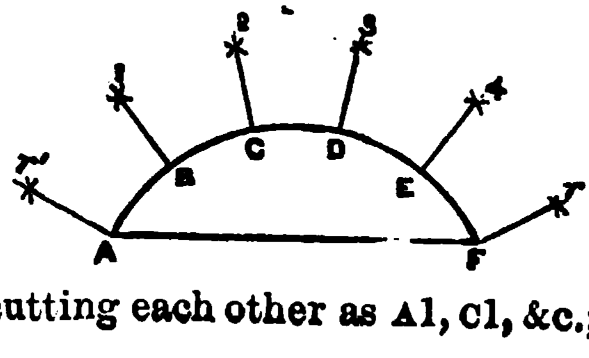
Fig. 23.



With the radius A*d*, equal to one-fourth of the length of the chord of the arc AB, and from A as a centre, cut the arc in *c*; also from B as a centre with the same radius cut the chord in *b*; draw the line *cb*, and twice the length of the line *cb* is the length of the arc nearly.

5. *To draw from or to the circumference of a circle lines tending towards the centre, when the centre is inaccessible.* (Fig. 24.)

Fig. 24.

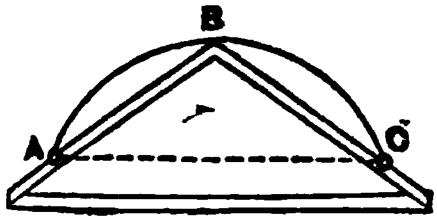


Divide the given portion of the circumference into the desired number of parts; then with any radius less than the distance of two parts, describe arcs cutting each other as A1, C1, &c.;

draw the lines B1, C2, &c., which will lead to the centre, as required. *To draw the end lines* Ar', Fr from B and E, with the same radii as before describe the arcs r', r, and with the radius B1, from A as centre, cut the former arcs at r', r, lines then drawn from Ar' and Fr will tend towards the centre, as required.

6. *To describe an arc of a circle of large radius.* (Fig. 25.)

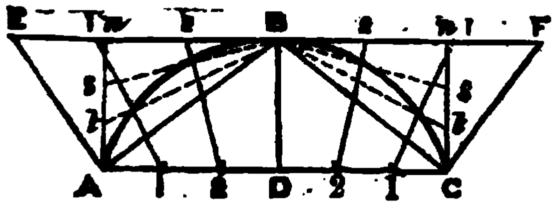
FIG. 25.



Let A, B, C be the three points through which the arc is to be drawn; join BA and BC; then construct a flat triangular mould, having two of its edges perfectly straight and making with each other an angle equal to ABC. Each of the edges should be a little longer than the chord AC. In the points A, C fix pins; and fix a pencil to the mould at B, and move the mould so as to keep its edges touching the pins at A and C, when the pencil will describe the required arc.

7. *Another method.* (Fig. 26.)

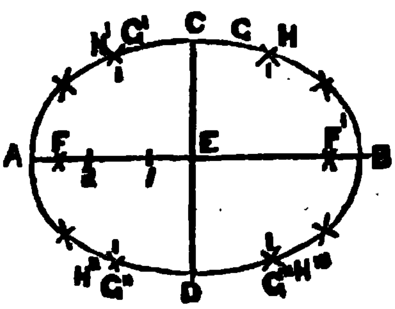
FIG. 26.



Draw the chord ADC, and draw EBF parallel to it; bisect the chord in D and draw DB perpendicular to AC; join AB and BC; draw AE perpendicular to AB and CF perpendicular to BC; also draw An and Cn perpendicular to AC; divide AC and EF into the same number of equal parts, and An, Cn into half that number of equal parts; join 1 and 1, 2 and 2, also B and s, s, and B, and t, t; through the points where they intersect describe a curve, which will be the arc required.

8. *To describe an ellipse, the transverse and conjugate diameters being given.* (Fig. 27.)

FIG. 27.



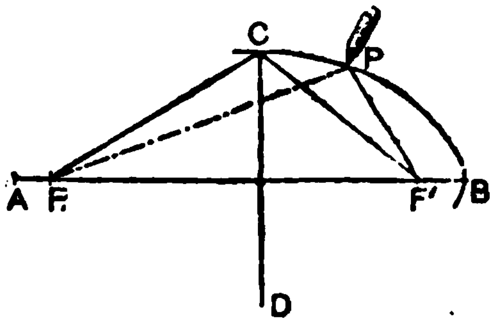
Let AB be the transverse and CD the conjugate diameters, bisecting each other at right angles in the centre E; from C as a centre, with EA as radius, describe arcs cutting AB in F and F′, which will be the foci of the ellipse; between E and F set off any number of points, as 1, 2 (it is advisable that these points should be closer as they approach F).

From F and F′, with radius B1, describe the arcs G, G′, G″, G‴.

From F and F′, with radius A1, describe the arcs H, H′, H″, H‴, intersecting the arcs G, G′. G″, G‴ in the points I, I, I, I, which will be four points in the curve.

Then strike arcs from F, F′ first with A2, then with B2; these radii intersecting will give four more points. Proceed in this way with all the points between E and F; the curve of the ellipse must then be traced through these points by hand.

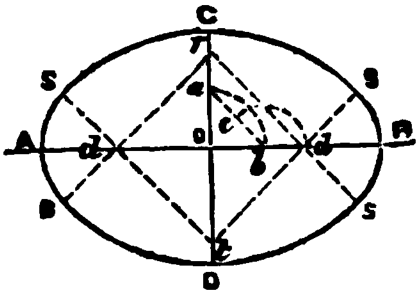
FIG. 28.



9. *Another method.* (Fig. 28.)

Let AB and CD be the axes; find F, F′, the two foci as before; join CF, CF′; make an endless thread equal in length to the perimeter of the triangle CFF′, and passing it round two drawing-pins at F and F′, draw it taut by means of a pencil-point P, so as to make a triangle PFF′ equal in perimeter to CFF′; move the pencil-point P along, keeping the thread taut, and the required curve will be described.

FIG. 29.

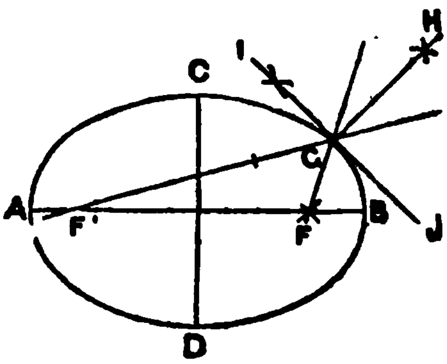


10. *Another method.* (Fig. 29.) (Approximate.)

At *o*, the intersection of the two diameters, as a centre, with a radius equal to the difference of the semi-diameters, describe the arc *ab*, and from *b* as a centre with half the chord *boa* describe the arc *cd*; from *o* as centre with the distance *od* cut the diameters in *dr*, *dt*; draw the lines *rs*, *rs*, *ts*, *ts*, then from *r* and *t* describe the arcs SDS, SCS; also from *d* and *d* describe the smaller arcs SAS, SBS, which will complete the ellipse required.

11. *To draw a tangent and a perpendicular to an ellipse at any point.* (Fig. 30.)

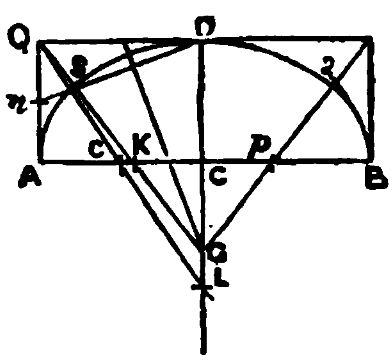
FIG. 30.



Let G be the point; from F, F′, the two foci of the ellipse, draw straight lines through G and produce them; bisect the angle made by the produced parts, by GH, then GH is perpendicular to the curve; at G bisect the angle formed by FG and F′G produced, by IJ, then IJ will be the tangent to the curve at G, and it will also be perpendicular to GH.

12. *To describe an elliptic arc, the span and height being given.* (Fig. 31.) (Approximate.)

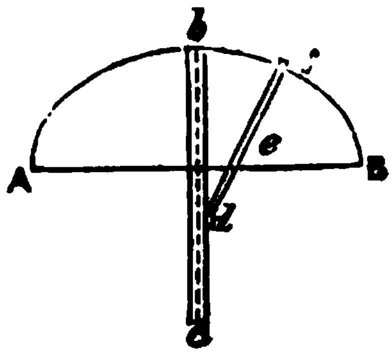
FIG. 31.



Bisect with a line at right angles the chord or span AB; erect the perpendicular AQ, and draw the line QD equal and parallel to AC; bisect AC in *c*, and AQ in *n*; make CL equal to CD, and draw the line L*c*Q; draw also the line *n*SD, and bisect SD with a line KG at right angles to it, and meeting the line LD in G; draw the line GKQ, and make C*p* equal to CK, and draw the line G*p*2; then from G as centre with the radius

GD describe the arc SD2, and from K and *p* as centres with the radius AK describe the arcs AS and 2B, which complete the arc, as required.

FIG. 32.



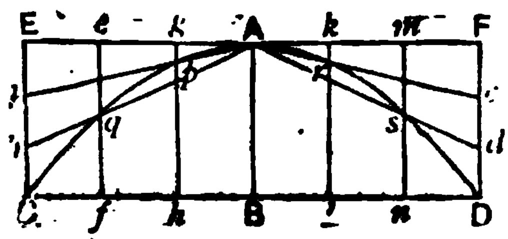
13. *Another method.* (Fig. 32.)

Bisect the chord AB, and fix at right angles to it a straight guide, as *bc*; prepare of any material a rod or staff equal to half the length of the chord, as *def*; at a distance from the end of the staff, equal to the height of the arc, fix a pin *e*, and at the extremity a tracer *f*; move the staff, keeping its end to the guide and the fixed pin to the chord, and the tracer will describe a half of the arc required.

14. *To describe a parabola when its height and base are given.* (Fig. 33.)

Let CD be the base and AB the height; set them off as shown in the figure, so that CB = CD, and complete the rectangle CDFE; divide EC and FD into any number of equal parts, say three, at *a*, *b*, *c*, and *d*; join A*a*, A*b*, A*c*, A*d*; divide AE, AF, BC, and BD into the same number of equal parts at *e*, *g*, *k*, *m*, *f*, *h*, *l*, *n*; join *ef*, *gh*, *kl*, *mn*, cutting A*b*, A*a*, A*c*, A*d* at *q*, *p*, *r*, and *s*. A line drawn through C *q p* A *r s* D will be the parabola required.

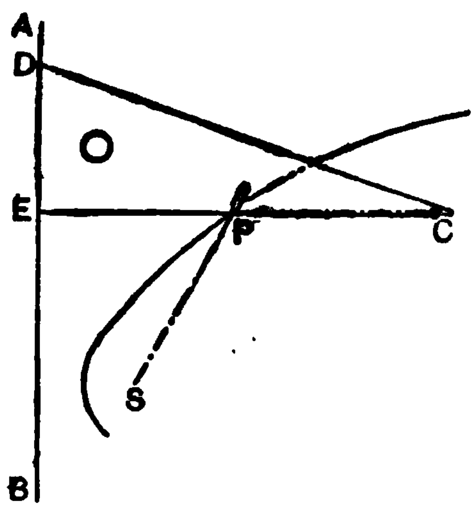
FIG. 33.



15. *Another method, when the directrix and focus are given.* (Fig. 34.)

Place a straight-edge to the directrix AB, and apply to it a square CDE; to the end C of the square fasten a thread, and pin the other end to S the focus, making the length of the thread equal to CE; slide the square along the straight-edge, holding the thread taut against the edge of the square by a pencil P, by which the curve is described.

FIG. 34.



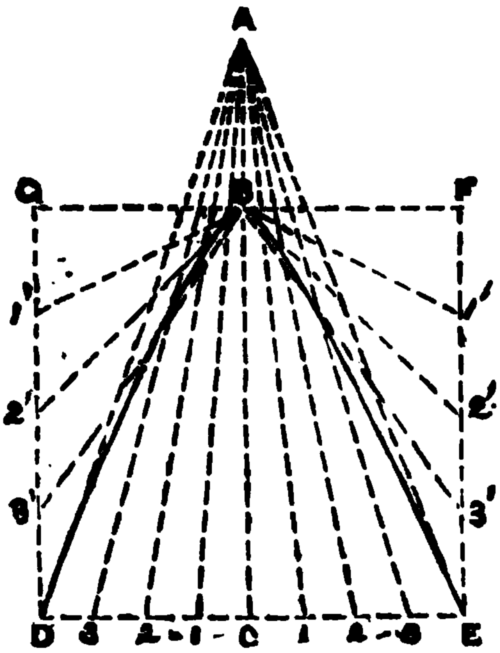
16. *To describe a hyperbola, the diameter, abscissa, and double ordinate being given.* (Fig. 34A.)

Let AB be the diameter, BC its abscissa, and DE its double ordinate; then through B draw GF parallel and equal to DE; draw also DG and EF parallel to the abscissa BC.

Divide DC and CE into the same number of equal parts, as 1,2, &c., and from the points of division draw lines meeting in A.

Divide GD and EF each into the same number of parts as DC or CE, and from the points of division 1′, 2′, &c., draw lines meeting in B.

FIG. 34A.

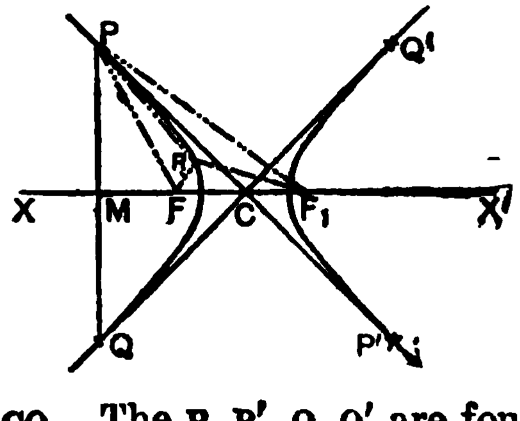


The points of intersection of the lines 1 and 1′, 2 and 2′, &c., thus found, will be points in the required curve.

17. *Another method, when the foci and a point on the curve are given.* (Fig. 34B.)

A hyperbola is a curve such that the difference of the distances of any point in the curve from the two foci is equal to the transverse axis; and this property suggests the following mechanical construction:—

FIG. 34B.



Let P (fig. 34B) be any point on the curve, and F and F_1 its foci; join FF_1 and produce it, making XX′ the axis; draw PM perpendicular to XX′, and produce it to Q, making MQ equal to PM; bisect FF_1 at C, and produce PC, QC, to CP′, CQ′, making them equal to CP or CQ. The P, P′, Q, Q′ are four points on the curve. From one of them, say P, stretch two pieces of string PF and PF_1, fastening them to the paper at F and F_1, and simply knotting them at P; slip a small bead over them at P, and taking hold of P and keeping the thread taut, slide the bead along the threads, and the bead will describe the curve as far as the axis. Repeat this process at P′, Q, and Q′.

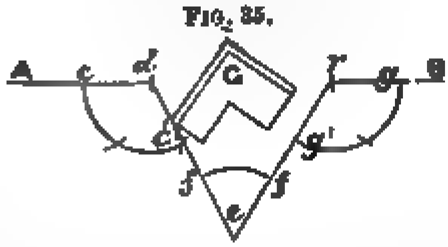
18. *To describe a rectangular hyperbola, given the asymptotes and a point on the curve.* (Fig. 34c.)

FIG. 34c.

Let OX, OY be the asymptotes, and P the given point. Draw PM parallel to OY, and PS parallel to OX; set off any ordinates (generally equidistant for convenience) 11, 22, 33, 44, 55, 66, and join O to the intersections of these ordinates with PS, cutting PM at 1′, 2′, 3′, &c.; through 1′ draw 1′I parallel to OX, cutting 11 in I; through 2′, 2′II cutting 22 in II, and so on for III, IV, V, and VI; then P, I, II, III, &c., are points on the required curve.

19. *To obtain by measurement the length of any direct line, though intercepted by some material object.* (Fig. 35.)

FIG. 35.



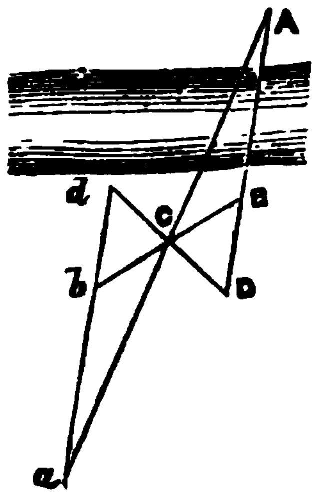
Suppose the distance between A and B is required, but the straight line is intercepted by the object G. On the point *d*, with any convenient radius, describe the arc *cc′*, and make the arc twice the radius *dc* in length; through *c′* draw the line *dc′e*, and on *e* describe another arc *ff* equal in length to the radius *dc*; draw the line *efr* equal to *efd*; from *r* describe the arc *g′g*, equal in length to twice the radius *rg*; continue the line through *rg* to B: then A and B will make a right line, and *de* or *er* will equal the distance between *dr*, by which the distance between AB is obtained, as required.

20. *To ascertain the distance geometrically of an inaccessible object on a level plane.* (Fig. 36.)

FIG. 36.

Let it be required to find the distance between A and B, A being inaccessible. Produce AB to any point D, and bisect BD in C; through D draw D*a*, making any angle with DA, and take DC and DB respectively and set them off on D*a* as D*b* and D*c*; join B*c*, C*b*, and A*b*; through E, the intersection of B*c* and C*b*, draw DEF meeting A*b* in F; join BF and produce it till it meets D*a* in *a*: then *ab* will be equal to AB, the distance required.

FIG. 37

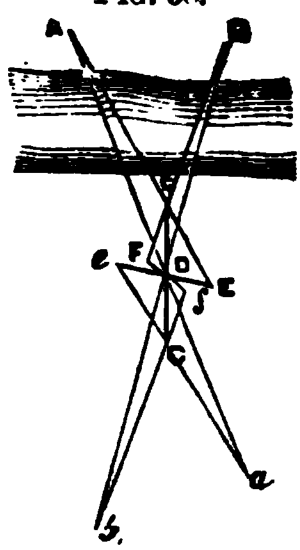


21. *Another method.* (Fig. 37.)

Produce AB to any point D; draw the line D*d* at any angle to the line AB; bisect the line D*d* in C, through which draw the line B*b*, and make C*b* equal to BC; join AC and *db*, and produce them till they meet at *a*: then *ba* will equal BA, the distance required.

22. *To measure the distance between two objects, both being inaccessible.* (Fig. 38.)

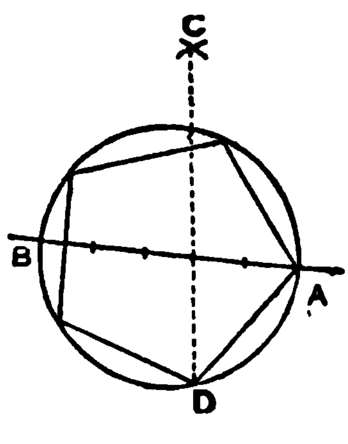
FIG. 38.



Let it be required to find the distance between the points A and B, both being inaccessible. From any point C draw any line C*c*, and bisect it in D; produce A*c* and B*c*, and prolong them to E and F; take the point E in the prolongation of A*c*, and draw the line ED*e*, making D*e* equal to DE.

In like manner take the point F in the prolongation of B*c*, and make D*f* equal to DF; produce AD and *e*C till they meet in *a*, and also produce BD and *f*C till they meet in *b*: then the distance between the points *a* and *b* equals the distance between the inaccessible points A and B.

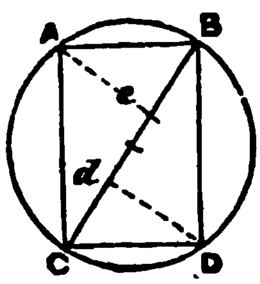
FIG. 39.



23. *To inscribe any regular polygon in a given circle.* (Fig. 39.)

Divide any diameter AB of the circle ABD into as many equal parts as the polygon is required to have sides; from A and B as centres, with a radius equal to the diameter, describe arcs cutting each other in C; draw the line CD through the second point of division on the diameter AB, and a line drawn from D to A is equal to one side of the polygon required.

FIG. 40.

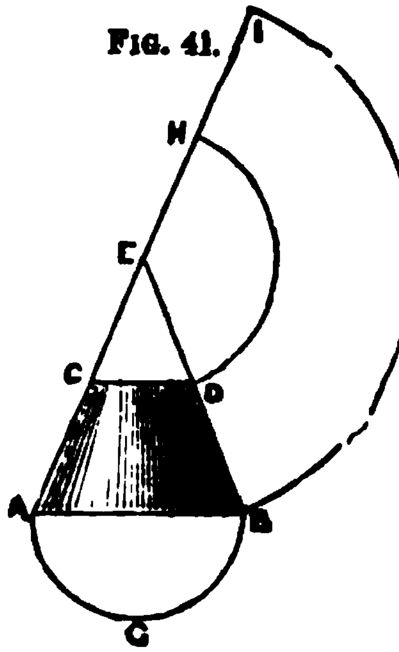


24. *To cut a beam of the strongest section from any round piece of timber.* (Fig. 40.)

Divide any diameter CB of the circle into three equal parts; from *d* or *e*, the two points of division in CB, erect a perpendicular cutting the circumference of the circle in D or A; draw CD and DB, also AC equal to DB and AB equal to CD: the rectangle ABCD will be the section of the beam required.

25. *To describe the proper form of a flat plate by which to construct any given frustum of a cone.* (Fig. 41.)

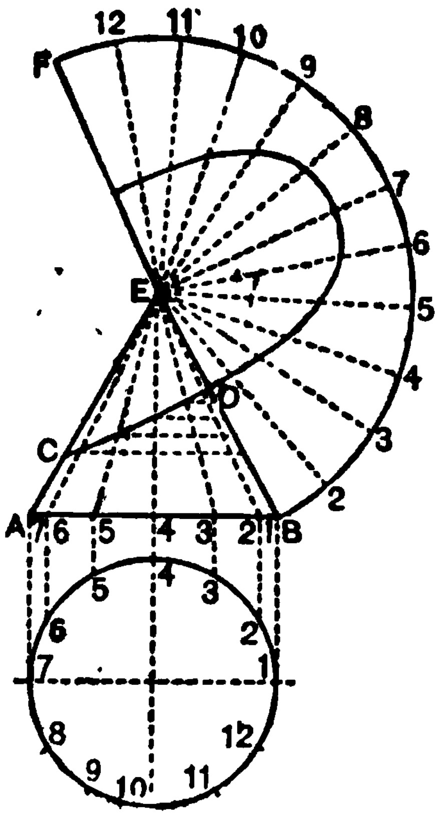
FIG. 41.



Let ABCD represent the required frustum of a cone; continue the lines AC and BD till they meet in E; from E as a centre, with ED as radius, describe the arc DH, and from the same centre, with EB as radius, describe the arc BI; make BI equal in length to twice AGB, equal to the circumference of the base of the cone; draw the line EI: then BDHI is the form of the plate required.

26. *To find the development of the frustum of a right cone when cut by an angle inclined to the base.* (Fig. 42.)

FIG. 42.



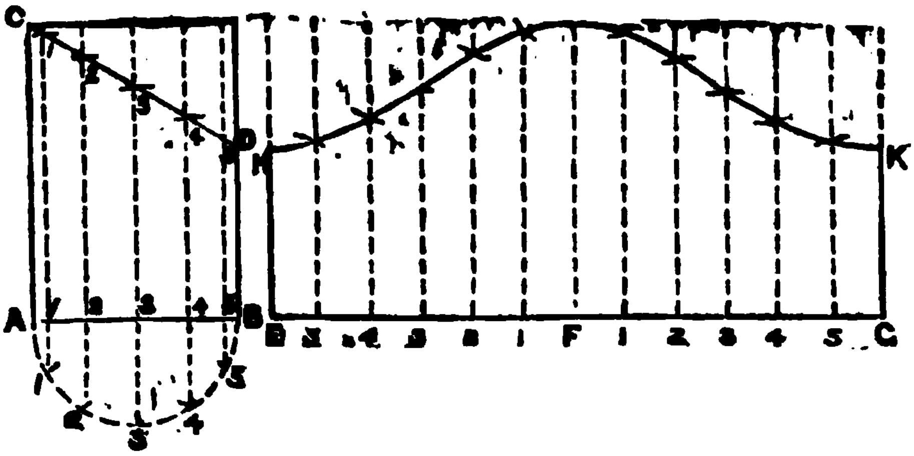
Let ABCD represent the required frustum of the cone; continue the lines AC and BD till they meet at E; divide the base of the cone into any number of equal parts—say 12—in the points 1, 2, 3, &c.; join these points to E; next find the development of the base of the cone, as shown in the preceding example, and on it set off the same number of points —viz. 12—and draw lines from them to E; project the points of intersection of each of the lines E1, E2, E3, &c., with the line CD, horizontally on to either of the slant sides (say EB); then from E as centre measure the distance down along EB to the foot of each projection and set it off on the corresponding numbers (measuring from E) in the development: a line drawn through these points will give the curve of the top of the section, as required.

27. *To find the development of the frustum of a cylinder when cut by a plane inclined to the base.* (Fig. 43.)

Let ABCD represent the required frustum of a cylinder; divide the base into any number of equal parts—say 12— and draw lines through those points on the cylinder parallel to AC and BD; draw a line EFG equal in length to the circumference of the cylinder, and divide it into the same number of parts; on each point of division set up perpendiculars to it, making EH and GK equal in length to BD, and make FI equal

in length to AC; then take the height at 1 and set it up on the corresponding number on each side of FI, and so on with each

FIG. 43.



number: a line traced through the points thus obtained will be the curve of the required development.

28. *To find the development of any given portion of a segment of a sphere.* (Figs. 44, 45, and 46.)

FIG. 44.

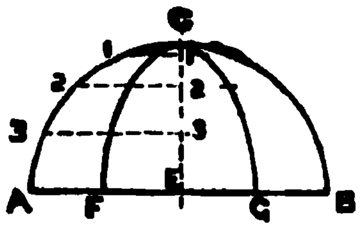


FIG. 46.

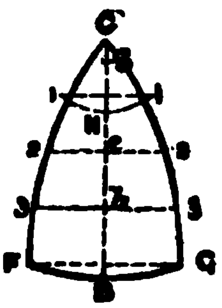


FIG. 45.

Let ABC (fig. 44) be the middle section of the segment, and CFG in the plan (fig. 45) the portion to be developed; bisect AB (fig. 44) in E, and set up the perpendicular EC; divide the arc AC into any given number of equal parts—say, four—and through the points of division draw the lines 1 1, 2 2, &c., parallel to AB; on the plan (fig. 45) from C as a centre, with the radius 1 1 taken from fig. 44, draw the arcs 1 1 cutting FC and CG in 1 and 1, and so on with 2 2 and 3 3; draw any line BC (fig. 46), making it equal in length to BC (fig. 44), and on it set off the same number of equal parts; at each point of division draw lines perpendicular to BC, and number them the same as on fig. 44.

Measure the length of the arc 1 1 in fig. 45, and set off half of it on each side of BC on line 1 1, and so on with each arc, including FG; a line traced through the points thus obtained will give the curve of the sides of the given portion of the segment when it is developed. To describe the curve at the bottom of the figure, take one-fourth of the circumference of the base as a radius, and from F and G as centres describe arcs cutting BC in S; then from S as centre, with the same radius, describe the arc FBG, which will be the curve of the bottom of the figure, as required.

Should the top of the figure be cut off at the line 1 1 (fig. 44),

from S as a centre in fig. 46 describe the arc 1H1, which will be the curve of the top of the figure, as required.

29. *To find the development of any given portion of a paraboloid.* (Figs. 47, 48, and 49.)

The development is found in the same manner as that of a portion of a segment of a sphere, as described in the last example (No. 28), with but one exception—that is, the length of the radius for describing the bottom curve of the figure, which instead of being equal to one-fourth of the circumference, as in example No. 28, is equal to one-half the length of the arc ACB (fig. 47) in this example.

FIG. 47.

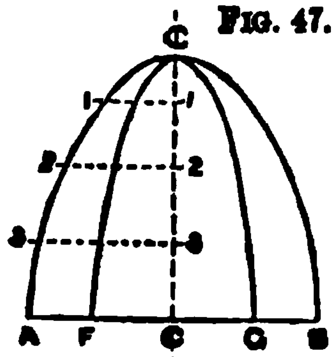


FIG. 49.

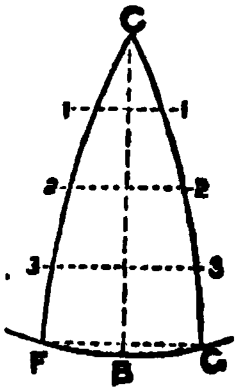
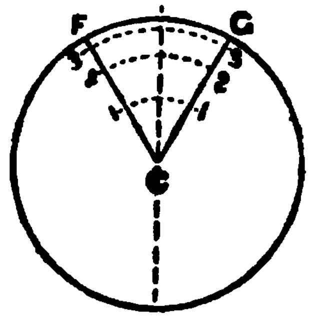


FIG. 48.



30. *To find the development of an entablature plate.*

Let fig. 50 be the side elevation, fig. 51 the front elevation, fig. 52 the plan, and fig. 53 the development of the figure;

FIG. 50. FIG. 51.

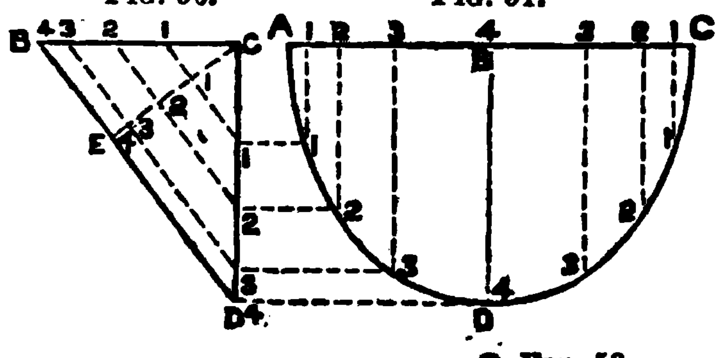


FIG. 52.

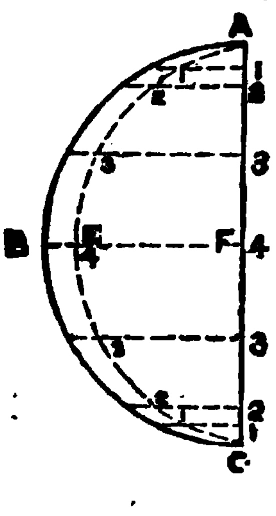
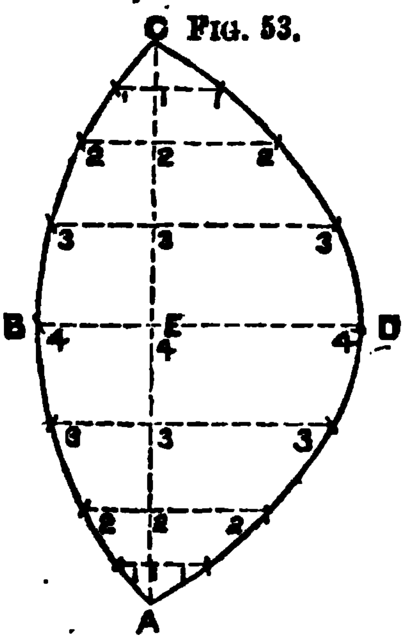


FIG. 53.



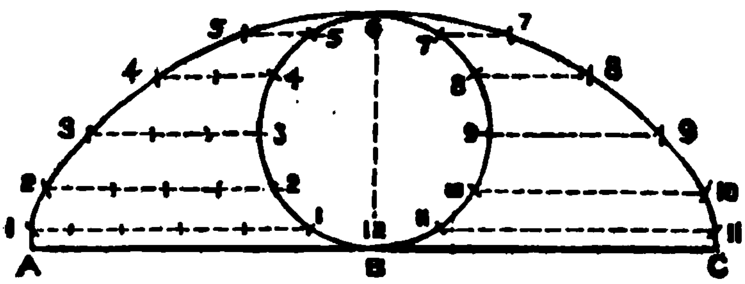
divide ADC (fig. 51) into eight equal parts, and from the points of intersection draw lines parallel to ABC, cutting CD (fig. 50)

in the points 1, 2, &c.; on BD (fig. 50) erect a perpendicular EC, and from the points on CD draw lines parallel to BED. From fig. 51 take the points 1, 2, &c., on ABC and set them off on AFC (fig. 52), and erect perpendiculars from AFC at these points. From C (fig. 50) along CE measure the points C, 1, C, 2, &c., and set them off on their corresponding lines from AFC in fig. 52; draw a line through those points, then measure it with its divisions and set it off in fig. 53 as a straight line AEC, and at the points of division erect perpendiculars, continuing them either side of the line AEC; measure the distances 1, 1; 2, 2. &c. (fig. 50), on either side of CE, and set them off from AEC (fig. 53) on their corresponding lines, and on their respective sides of AEC. These will give the development.

31. *To describe a cycloid, the generating circle being given.* (Fig. 54.)

Let B6 be the generating circle; draw a line ABC, equal to the circumference of the generating circle, by dividing the circle into any number of given parts, as 1, 2, 3, &c., and setting off half that number of parts on each side of B; draw lines from the intersections of the circle 1, 2, 3, &c., 7, 8, 9, &c.,

FIG. 54.

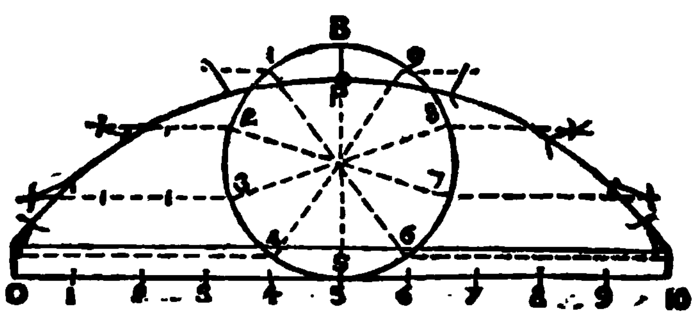


parallel to AC; set off one division of the circle outwards on the first lines 5 and 7, two divisions on the next lines 4 and 8, then three on the next, and so on: then the intersection of those points on the lines 1, 2, 3, &c., will be points in the curve.

32. *To describe a prolate cycloid, the generating circle and the position of the generating point being given.* (Fig. 55.)

Let 5B be the generating circle, and P the generating point; draw the base line 010 equal in length to the circumference of

FIG. 55.



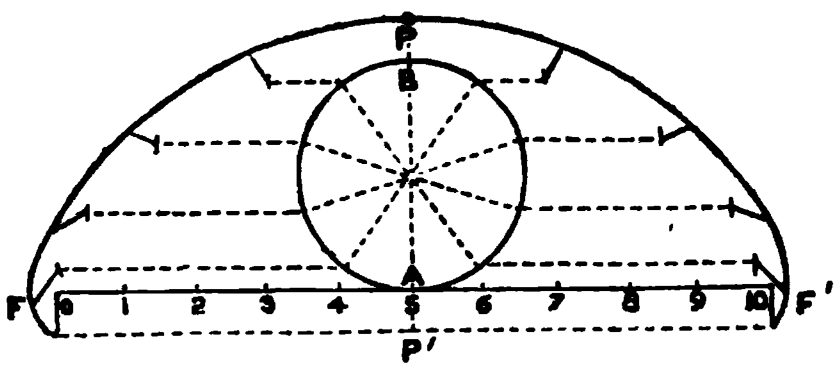
the circle; divide the circle into any number of equal parts—say, 10—and draw the radii 1, 2, 3, &c.; from each of these points

in the circle draw lines parallel to 010; as in the cycloid, mark off one division on the lines 1 and 9, two divisions on the lines 2 and 8, three on the next, and so on; at the end of each line draw a line parallel to the radius from which it springs, and set on it the distance BP: a line traced through the points so obtained will be the curve required.

33. *To draw a curtate cycloid, the generating circle and position of the generating point being given.* (Fig. 56.)

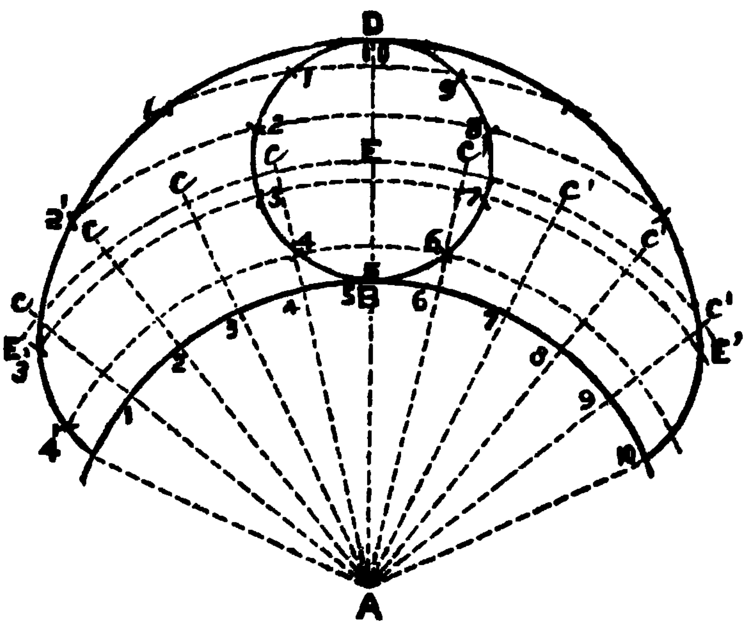
Let AB be the generating circle, and P the generating point without; draw the base line FF′ equal to the circumference of

FIG. 56.



the circle AB, divide the circumference into any number of equal parts—say, 10—and draw the radii 1, 2, 3, &c.; from each of these points in the circle draw lines parallel to the base line FF′; also draw the line GG′ parallel to it, and at the same distance from it as the generating point is from the circle; as in the cycloid, mark off one division on the first line, two on the second, and so on; from the ends of the lines thus found draw lines parallel to the radius from which the line springs, and set off on them the distance BP: a line traced through the points thus found will be the curve required.

FIG. 57.



34. *To describe an epicycloid, the generating circle and the directing circle being given.* (Fig. 57.)

Let BD be the generating circle, and AB the directing circle; divide the generating circle into any number of equal parts—say, 10—as 1, 2, 3, &c., and set off the same distances round the directing circle; draw radial lines from A through these last

points, and produce them to an arc drawn with A as centre and AE as radius, as shown by *cccc* and *c'c'c'c'* on the diagram; draw concentric arcs also through all the points on the generating circle, with A as centre; then taking *c*, *c*, *c*, *c* and *c'*, *c'*, *c'*, *c'* as centres, and BE as radius, describe arcs cutting the concentric circles at 1', 2', &c.: the points thus found will be points in the required curve.

FIG. 58.

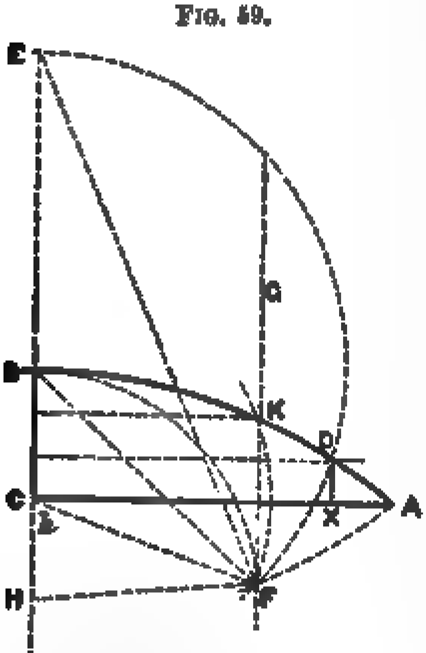
A

35. *To describe a hypocycloid, the generating circle and the directing circle being given.* (Fig. 58.)

Proceed as in the epicycloid, the exception being that the construction lines are drawn within the directing circle instead of outside, as in the epicycloid.

36. *To construct a neoid curve, the length, extreme half-breadth, and approximate fineness being given.* (Fig. 59.)

FIG. 59.



Let BC be the extreme half-breadth, and CA the length.

In CA take CX equal to CA × $\frac{6}{8}$, co-efficient of fineness, and at X set up the ordinate XD equal to $\frac{1}{3}$ of BC.

About B and through D describe the circular arc FDE, cutting CB produced, in E.

About E through A describe the circular arc AF, cutting the former arc in F, which will be the focus.

Through F draw FG parallel to BC.

Join FB and FE, and draw FH, making the angle BFH equal to the angle BFG, and cutting BC, produced if necessary, in H; divide the angle HFE (equal to $\frac{2}{3}$ of BFG) into a convenient number of equal parts by lines diverging from F and cutting HE in a series of points, such as *h*.

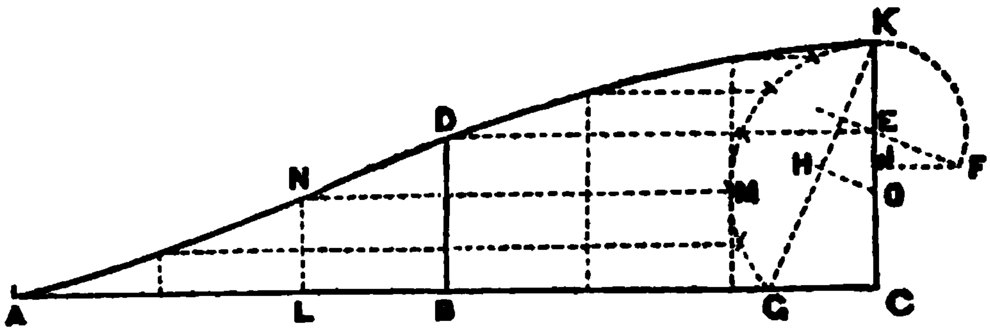
The points H, B, and E will be three of the points required. About the series of the points thus found describe circular arcs through the focus F. Divide BC into the same number of parts as the angle HFE, and through the points of division draw straight lines parallel to CA.

The points, such as K, where these lines cut the arcs re-

spectively corresponding to them, will be points in the required curve.

37. *To construct an harmonic curve.* (Fig. 60.)

FIG. 60.

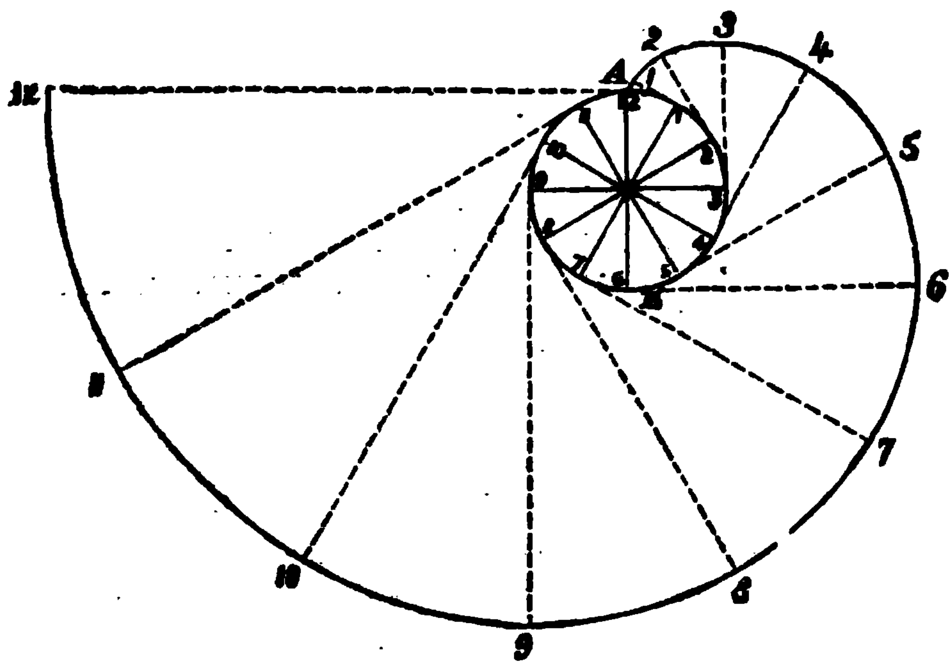


Let AC be the base, CK the greatest ordinate, and BD a balance ordinate midway between AC (the length of this ordinate varies according to the degree of fineness required in the curve, but it should not be greater than $\frac{3}{4}$, nor less than $\frac{1}{2}$, of CK); then through D parallel to AC draw DE, cutting CK in E; bisect CK in J, through which point draw JF parallel to AC; about E with the radius EK describe a circular arc, cutting JF in F; join FE and produce it, and at right angles to it draw KG.

Bisect KG in H, and from H erect a perpendicular to KG, cutting CK in O, from which as a centre describe the arc KMG; divide the base CA into any number of equal parts, and also divide the arc KMG into the same number of equal parts; through each point of division of the arc, as M, draw lines parallel to AC, and through each point of division of the base, as L, draw perpendiculars cutting the lines parallel to the base: the points of intersection of the lines will be points required in the curve, as N.

38. *To describe the involute of a circle.* (Fig. 61.)

FIG. 61.



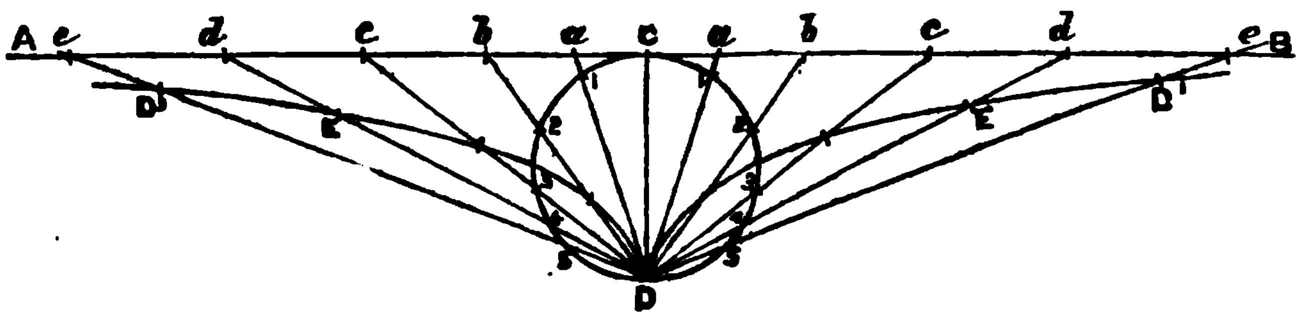
Let AB be the given circle, which divide into any equal number of parts—say, 12—as 1, 2, 3, &c.; from the centre draw

radii to these points; then draw lines (tangents) at right angles to these radii. On the tangent to radius No. 1 set off from the circle a distance equal to one part, and on each of the tangents set off the number of parts corresponding to the number of its radius, so that No. 12 has twelve divisions set off on it (that is, equal to the circumference of the circle): a line traced through the ends of these lines will be the curve required.

39. *To describe a cissoid.* (Fig. 62.)

Draw any line AB, and drop a perpendicular CD from it; on CD describe a circle; from the extremity D of the diameter draw any number of lines, any distance apart, passing through

FIG. 62.

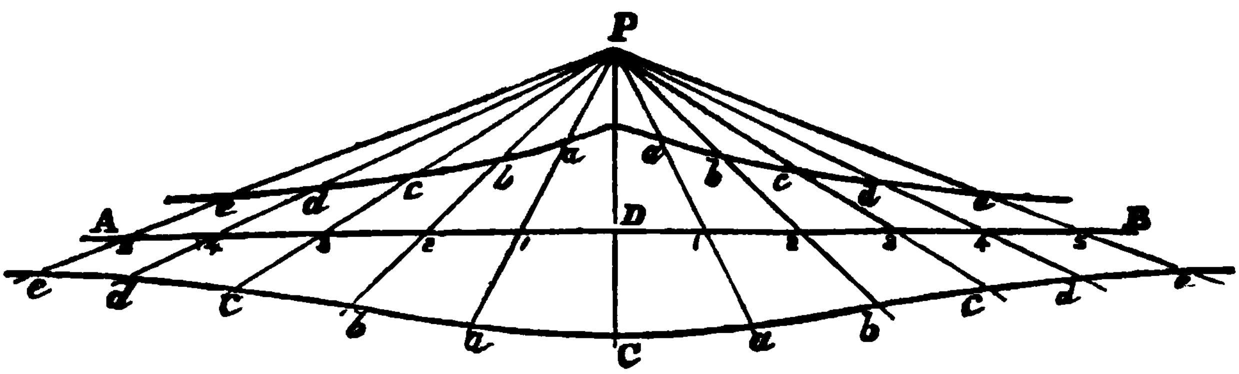


the circle and meeting the line AB in a, b, c, d, and e; take the length from D to 5, and set it off on the same line on each side from e, as eD′; set off the length D4 from d, as dE. Proceed thus with all the lines, and trace the curve through the points so obtained.

40. *To describe a conchoid, the asymptote, pole, and diameter being given.* (Fig. 63.)

Let AB be the asymptote, P the pole, and C the diameter; draw CD at right angles to AB; on each side of D set off any number of equal parts, as 1, 2, 3, &c.; from P draw lines passing

FIG. 63.



through the points 1, 2, 3, &c.; then from each of these points with radius CD describe arcs cutting these lines in a, b, c, &c.: the points of intersection will be points in the curve. The curve above the asymptote is called the superior conchoid, and the curve obtained by setting off the same lengths under the asymptote is called the inferior conchoid.

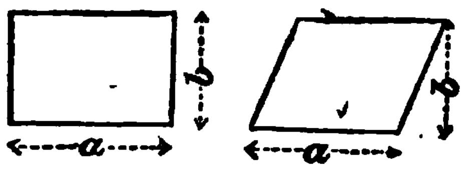
MENSURATION.

I. Mensuration of Superficies.

PROBLEMS.

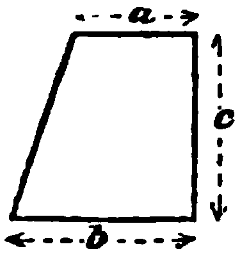
1. *To find the area of any parallelogram.* (Fig. 64.)

Fig. 64.



Rule. — Multiply the length by the perpendicular height, and the product will be the area. Thus if A = the area, a = the length, and b = the perpendicular height, then $A = ab$.

Fig. 65.

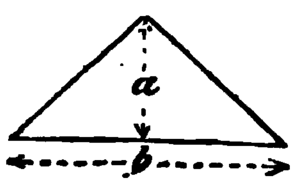


2. *To find the area of a trapezoid.* (Fig. 65.)

Rule.—Multiply the sum of the parallel sides by the perpendicular distance between them; half the product will be the area. Thus if A = the area, b and a = the parallel sides, and c = the perpendicular distance between them, then $A = \frac{(a+b)c}{2}$.

3. *To find the area of any triangle.* (Fig. 66.)

Fig. 66.

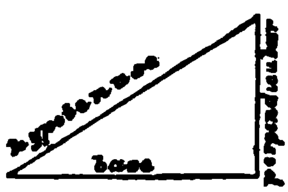


Rule.—Multiply the base by the perpendicular height; half the product will be the area. Thus if A = the area, b = the base, and a = the perpendicular height, then $A = \frac{ab}{2}$.

4. *To find the third side of a right-angled triangle, two being given.* (Fig. 67.)

(I.) When the base and perpendicular are given, to find the hypotenuse, or longest side.

Fig. 67.



Rule.—To the square of the base add the square of the perpendicular; the square root of the sum will equal the hypotenuse.

(II.) When the hypotenuse and one side are given, to find a third side.

Rule.—Multiply the sum of the hypotenuse and one side by their difference; the square root of the product will be the other side.

If b = the base, c = the perpendicular, and a = the hypotenuse, then

$$a = \sqrt{b^2 + c^2}$$

$$b = \sqrt{(a+c)\ (a-c)} = \sqrt{a^2 - c^2}$$

$$c = \sqrt{(a+b)\ (a-b)} = \sqrt{a^2 - b^2}$$

5. *To find the area of any regular polygon.* (Fig. 68.)

RULE.—Multiply the sum of its sides by a perpendicular drawn from the centre of the polygon to one of its sides; half the product will be the area. Thus if A = the area, c = the number of sides, b = the length of one side, and a = the perpendicular, then $A = \frac{abc}{2}$.

FIG. 68.

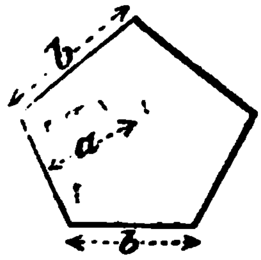


TABLE OF REGULAR POLYGONS.

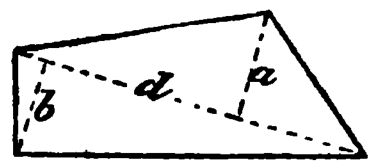
A = the angle contained between any two sides.
R = the radius of the circumscribed circle.
r = the radius of the inscribed circle.
S = the side of the polygon.

No. of Sides	Name	A	R=S×	r=S×	S=R×	S=r×	Area=S^2×
3	Trigon .	60°	·57735	·28868	1·73205	3·46410	·43301
4	Tetragon .	90°	·70711	·50000	1·41421	2·00000	1·00000
5	Pentagon .	108°	·85065	·68819	1·17557	1·45309	1·72048
6	Hexagon .	120°	1·00000	·86603	1·00000	1·15470	2·59808
7	Heptagon .	$128\frac{4}{7}$°	1·15238	1·03826	·86777	·96315	3·63391
8	Octagon .	135°	1·30656	1·20711	·76537	·82843	4·82843
9	Nonagon .	140°	1·46190	1·37374	·68404	·72794	6·18182
10	Decagon .	144°	1·61803	1·53884	·61803	·64984	7·69421
11	Undecagon	$147\frac{3}{11}$°	1·77473	1·70284	·56347	·58725	9·36564
12	Duodecagon	150°	1·93185	1·86603	·51764	·53590	11·19615

6. *To find the area of a trapezium.* (Fig. 69.)

RULE.—Multiply the diagonal d by the sum of the two perpendiculars a and b let fall upon it from the opposite angles; half the product will be the area. Thus if A = the area, a and b = the perpendiculars, and d = the diagonal, then

FIG. 69.



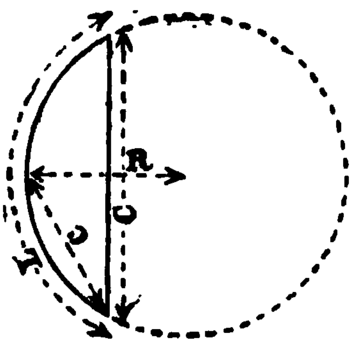
$$A = \frac{(a + b)\,d}{2}.$$

7. *To find the circumference of a circle, the diameter being given; or to find the diameter of a circle, the circumference being given.*

RULE.—Multiply the diameter by 3·1416, the product will be the circumference; or divide the circumference by 3·1416, the quotient will be the diameter.

8. *To find the length of any arc of a circle.* (Fig. 70.)

FIG. 70.



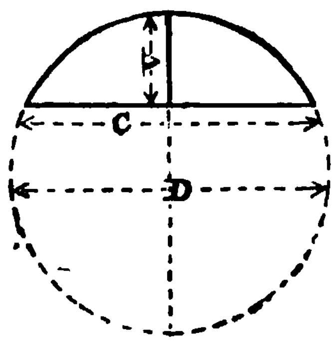
RULE (I.)—From eight times the chord of half the arc subtract the chord of the whole arc; one-third of the remainder will be the length of the arc, nearly. Thus if L = length of the arc, C = chord of the whole arc, c = chord of half the arc, then $L = \frac{8c - C}{3}$.

RULE (II.)—The radius being known, multiply together the number of degrees in the arc, the radius, and the number ·01745329; the product will be the length of the arc. Thus if L = length of the arc, D = degrees in the arc, R = radius, then

$$L = D \times R \times \cdot 01745329.$$

9. *To find the diameter of a circle, the chord and versed sine being given.* (Fig. 71.)

FIG. 71.

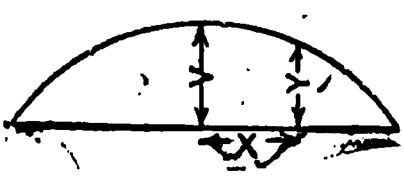


RULE.—Divide the square of half the chord by the versed sine, to the quotient add the versed sine, and the sum will be the diameter. Thus if D = the diameter, C = the chord, and V = the versed sine, then

$$D = \left\{ \frac{\left(\frac{C}{2}\right)^2}{V} + V \right\}$$

10. *To find the length of any ordinate of a segment of a circle.* (Fig. 72.)

FIG. 72.



RULE.—Find the radius of the arc of the segment (if not given) by the preceding formula; and from the square root of the difference of the squares of the radius and distance of the ordinate from the centre of the segment, subtract the radius; and to the result add the height of the segment, and the sum will be the required ordinate. Thus if R = the radius X = the distance of the ordinate from the centre of the segment, V = the height of the segment, and Y = the required ordinate, then

$$Y = \sqrt{R^2 - X^2} - R + V.$$

11. *To find the area of a circle.*

RULE (I.)—Multiply the square of the diameter by ·7854, and the product will equal the area, nearly. Thus if A = the area, D = the diameter, then $A = D^2 \times \cdot 7854$.

RULE (II.)—Multiply the square of the circumference by ·07958, and the product will be the area. Thus if A = area, C = circumference, then $A = C^2 \times \cdot 07958$.

Table of Properties of the Circle.

π	$= 3{\cdot}141592653589793 23846$	$\sqrt{2}$	$= 1{\cdot}41421356237309504880$
$\frac{\pi}{2}$	$= 1{\cdot}57079632679489661923$	$\sqrt{\frac{1}{2}}$	$= {\cdot}70710678118654752440$
		$2\sqrt{\pi}$	$= 3{\cdot}54490770181103205460$
$\frac{\pi}{4}$	$= {\cdot}78539816339744830962$	$2\sqrt{\frac{1}{\pi}}$	$= 1{\cdot}12837916709551257390$
$\frac{\pi}{6}$	$= {\cdot}52359877559829887308$	$\frac{1}{2}\sqrt{\pi}$	$= {\cdot}88622692545275801365$
$\pi\sqrt{2}$	$= 4{\cdot}44288293815836624702$	$\frac{1}{8}\sqrt{\frac{1}{\pi}}$	$= {\cdot}07052369794346953587$
$\pi\sqrt{\frac{1}{2}}$	$= 2{\cdot}22144146907918312351$	2π	$= 6{\cdot}28318530717958647693$
$\sqrt{\pi}$	$= 1{\cdot}77245385090551602730$	$\frac{2}{\pi}$	$= {\cdot}63661977236758134308$
$\sqrt{\frac{1}{\pi}}$	$= {\cdot}56418958354775628695$		

In the following formulæ A = area, C = circumference, D = diameter, S = side of square.

Circumference	$= D \times \pi = R \times 2\pi = \sqrt{A} \times 2\sqrt{\pi}$
Diameter	$= C \times \frac{1}{\pi} = \sqrt{A} \times 2\sqrt{\frac{1}{\pi}}$
Radius	$= C \times \frac{1}{2\pi} = \sqrt{A} \times \sqrt{\frac{1}{\pi}}$
Area	$= R^2 \times \pi = D^2 \times \frac{\pi}{4}$
Side of equal square	$= R \times \sqrt{\pi} = D \times \frac{1}{2}\sqrt{\pi} = C \times \frac{1}{2}\sqrt{\frac{1}{\pi}}$
Side of inscribed square	$= D \times \sqrt{\frac{1}{2}} = C \times \frac{1}{\pi}\sqrt{\frac{1}{2}} = \sqrt{A} \times \sqrt{\frac{2}{\pi}}$
Diameter of equal circle	$= S \times 2\sqrt{\frac{1}{\pi}}$

Diameter of circumscribing circle $= S \times \sqrt{2}$

Circumference of circumscribing circle $= S \times \pi\sqrt{2}$

Circumference of equal circle $= S \times 2\sqrt{\pi}$

Area of inscribed square $= A \times \frac{2}{\pi}$

12. *To find the area of a sector of a circle.*

Rule (I.)—Multiply the length of the arc by the radius of the sector, and half the product will equal the area.

Note.—To find the length of the arc, see problem 8, p. 35.

A = area of sector, L = length of arc, R = radius.

RULE (II.)—Multiply the number of degrees in the arc by the area of the circle, and $\frac{1}{360}$ of the product will equal the area. Thus if A = area, D = number of degrees in the arc, a = area of circle, then

$$A = \frac{Da}{360}.$$

13. *To find the area of the segment of a circle.*

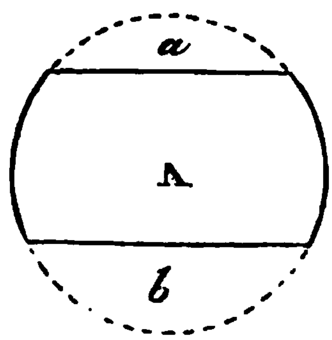
RULE (I.)—Find the area of a sector having the same arc as the segment; then deduct the area of the triangle contained between the chord of the segment and the radii of the sector. The remainder will be the area of the segment.

RULE (II.)—To two-thirds of the product of the chord and height of the segment, add the cube of the height divided by twice the chord; the sum will be the area of the segment, nearly. Thus if A = the area of the segment, C = the chord, and H = the height, then

$$A = \left(\frac{2CH}{3} + \frac{H^3}{2C}\right).$$

14. *To find the area of a circular zone.* (Fig. 73.)

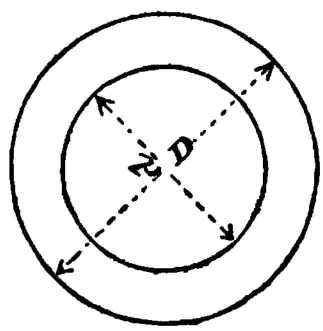
FIG. 73.



RULE.—Find the area of the circle of which the zone forms a part, and from it subtract the sum of the two segments of the circle formed by the zone; the remainder will be the area. Thus if A = area of the zone, a and b = the area of the two segments respectively, and C = area of the circle, then $A = C - (a + b)$.

15. *To find the area of a circular ring.* (Fig. 74.)

FIG. 74.

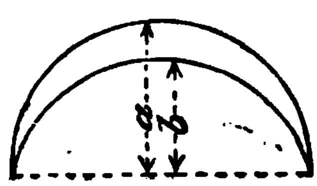


RULE.—Multiply the sum of the inside and outside diameters by their difference, and the result by ·7854; the product last obtained will be the area, nearly. Thus if A = area of ring, D = diameter of large circle, and d = diameter of small circle, then

$$A = \cdot 7854\{(D + d)\,(D - d)\}.$$

16. *To find the area of a lune.* (Fig. 75.)

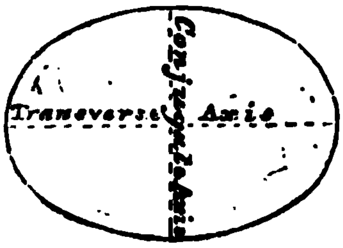
FIG. 75.



RULE.—Find the areas of the two segments formed by the lune; their difference will be the area required. Thus if A = area of lune, a = area of larger segment, and b = area of smaller segment, then $A = a - b$.

17. *To find the area of an ellipse.* (Fig. 54.)

FIG. 76.



RULE.—Multiply together the transverse and conjugate diameters of the ellipse, and the result by ·7854; the product will be the area, nearly. Thus if A = area of ellipse, a = the conjugate diameter, and b = the transverse diameter, then

$$A = ab \times \cdot 7854.$$

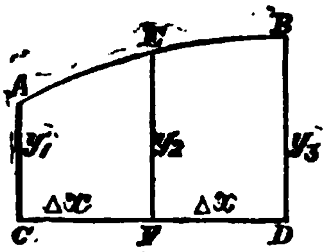
18. *To find the area of a cycloid.* (Fig. 54.)

RULE.—Multiply the area of its generating circle by 3.

19. *To find the area of a parabola.*

RULE.—Multiply the base by $\frac{2}{3}$ of the height.

FIG. 77.



20. *To find the area of a common parabola, or a parabola of the second order.* (Fig. 77.)

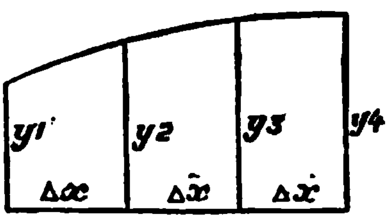
RULE.—To the sum of the two endmost ordinates add four times the intermediate ordinate; multiply the final sum by $\frac{1}{3}$ of the common interval between the ordinates. The result will be the area. Thus if y_1, y_2, and y_3 be the ordinates, Δx the common interval, and $\int y dx$ the area, then

$$\int y dx = \frac{\Delta x}{3}(y_1 + 4y_2 + y_3).$$

Remark.—The parabolic curve is said to be of the second order, the third order, &c., according to the exponent of the highest power of the abscissa. Thus a parabola of the first order is a straight line; a common parabola is a parabola of the second order, and so on.

21. *To find the area of a parabola of the third order.* (Fig. 78.)

FIG. 78.



RULE.—To the sum of the two endmost ordinates add three times the intermediate ordinates; multiply the final sum by $\frac{3}{8}$ of the common interval between the ordinates: the result will be the area. Thus if $\int y dx$ = the area, then

$$\int y dx = \frac{3\Delta x}{8}(y_1 + 3y_2 + 3y_3 + y_4).$$

TABLE SHOWING THE MULTIPLIERS FOR THE FOREGOING AND SOME OTHER RULES.

y_1, y_2, y_3, &c. = the ordinates, and Δx = the common interval or abscissa between the ordinates.

1. Trapezoidal rule,

$$\text{Area} = \frac{\Delta x}{2}(y_1 + y_2)$$

2. Rule for parabola of the second order,

$$\text{Area} = \frac{\Delta x}{3}(y_1 + 4y_2 + y_3)$$

3. Rule for parabola of the third order,

$$\text{Area} = \frac{3\Delta x}{8}(y_1 + 3y_2 + 3y_3 + y_4)$$

4. Rule for parabola of the fourth order,

$$\text{Area} = \frac{2\Delta x}{45}(7y_1 + 32y_2 + 12y_3 + 32y_4 + 7y_5)$$

5. Rule for parabola of the fifth order,

$$\text{Area} = \frac{5\Delta x}{288}(19y_1 + 75y_2 + 50y_3 + 50y_4 + 75y_5 + 19y_6)$$

6. Rule for parabola of the sixth order,

$$\text{Area} = \frac{\Delta x}{140}(41y_1 + 216y_2 + 27y_3 + 272y_4 + 27y_5 + 216y_6 + 41y_7)$$

22. *To measure any curvilinear area by means of the trapezoidal rule.*

RULE.—To the sum of half the two endmost ordinates add all the other ordinates, and multiply the sum by the common interval; the result will be the area. Thus

$$\int y dx = \Delta x\left(\frac{y_1 + y_n}{2} + y_2 + y_3 \ . \ . \ . \ . + y_{n-1}\right).$$

Remark.—In ship-building work it is very often convenient to perform the additions in the above rule mechanically, by measuring off the ordinates continuously on a long strip of paper, and measuring the total length on the proper scale. This rule is only approximate, but it is especially useful for getting the areas of the transverse sections in the first rough calculations of trim, displacement, &c.

23. *To measure any curvilinear area by means of the parabolic rule of the second order, or Simpson's first rule.*

RULE.—To the sum of the first and last ordinates add four times the intermediate ordinates and twice all the dividing

ordinates; multiply the final sum by $\frac{1}{3}$, the common interval: the result will be the area. Thus

$$\int y\,dx = \frac{\Delta x}{3}(y_1 + 4y_2 + 2y_3 + 4y_4 + 2y_5 \ldots . + 4y_{n-1} + y_n).$$

Remark.—The number of intervals in this rule must be even. The ordinates which separate the parabolas into which the figure is conceived to be divided, are called dividing ordinates, and all the other ordinates except the two endmost ones are called intermediate ordinates.

24. *To measure any curvilinear area by means of the parabolic rule of the third order, or Simpson's second rule.*

RULE.—To the sum of the two endmost ordinates add three times the intermediate ordinates and twice all the dividing ordinates; multiply the final sum by $\frac{3}{8}$, the common interval, and the result will be the area. Thus

$$\int y\,dx = \frac{3\Delta x}{8}(y_1 + 3y_2 + 3y_3 + 2y_4 + 3y_5 \ldots . + 3y_{n-1} + y_n).$$

The number of intervals in this case must be a multiple of three.

Remark.—The sequence of the multipliers in the two foregoing rules is obvious. Thus in the first rule the simple multipliers are 1 . 4 . 1, but they are combined thus:—

```
1 . 4 . 1
        1 . 4 . 1
                1 . 4 . 1
                        . . . . . .
                                  1 . 4 . 1
                                          1 . 4 . 1
                                                  1 . 4 . 1
-------------------------------------------------------------
1 . 4 . 2 . 4 . 2 . 4 . . . . . . . 4 . 2 . 4 . 2 . 4 . 1
```

In the second rule the multipliers are 1 . 3 . 3 . 1.

```
1 . 3 . 3 . 1
            1 . 3 . 3 . 1
                        1 . 3 . 3 . 1 . . . . .
                                              1 . 3 . 3 . 1
                                                          1 . 3 . 3 . 1
-----------------------------------------------------------------------
1 . 3 . 3 . 2 . 3 . 3 . 2 . 3 . 3 . . . . . . . . . 3 . 3 . 2 . 3 . 3 . 1
```

And in the same way the multipliers to measure any curvilinear area may be obtained from the table on p. 39.

25. *To measure any curvilinear area when subdivided intervals are used.*

1*st. When Simpson's first rule is used.*

RULE.—Diminish the multiplier of each ordinate belonging to a set of subdivided intervals in the same proportion in which

the intervals are subdivided. Multiply each ordinate by its respective multiplier as thus found, and treat the sum of their products as if they were whole intervals; that is, multiply the sum thus found by $\frac{1}{3}$ of a whole interval, and the product will be the area.

2nd. When Simpson's second rule is used.

RULE.—Proceed as in the first rule, but multiply by $\frac{3}{8}$ of a whole interval for the area.

Example to Simpson's First Rule.—The series of multipliers for whole intervals being 1 . 4 . 2 . 4 . 2, &c., those for half-intervals will be $\frac{1}{2}$, . 2 . 1 . 2 . 1, &c., and for quarter-intervals $\frac{1}{4}$. 1 . $\frac{1}{2}$. 1 . $\frac{1}{2}$, &c.

Remark.—When an ordinate stands between a larger and a smaller interval, its multiplier will be the sum of the two multipliers which it would have had as an end ordinate for each interval. Thus for an ordinate between a whole and a half interval the multiplier is $\frac{1}{2}+1=1\frac{1}{2}$, and between a half and a quarter interval $\frac{1}{2}+\frac{1}{4}=\frac{3}{4}$.

TABLE OF MULTIPLIERS WHEN SUBDIVIDED INTERVALS ARE USED.

Simpson's First Rule.

Ordinates	0	1	2	$2\frac{1}{3}$	$2\frac{2}{3}$	3	$3\frac{1}{3}$	$3\frac{2}{3}$	4	5	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8
Multipliers	1	4	$1\frac{1}{3}$	$1\frac{1}{3}$	$\frac{2}{3}$	$1\frac{1}{3}$	$\frac{2}{3}$	$1\frac{1}{3}$	$1\frac{1}{3}$	4	$1\frac{1}{2}$	2	1	2	$\frac{1}{2}$
Ordinates	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	4	5	$5\frac{1}{2}$	6	$6\frac{1}{4}$	$6\frac{1}{2}$	$6\frac{3}{4}$	7
Multipliers	$\frac{1}{2}$	2	1	2	1	2	$1\frac{1}{2}$	4	$1\frac{1}{2}$	2	$\frac{3}{4}$	1	$\frac{1}{2}$	1	$\frac{1}{4}$
Ordinates	0	1	2	$2\frac{1}{2}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{6}$	$4\frac{1}{3}$	$4\frac{1}{2}$	$4\frac{2}{3}$	$4\frac{5}{6}$	5
Multipliers	1	4	$1\frac{1}{2}$	2	$\frac{3}{4}$	1	$\frac{1}{2}$	1	$\frac{5}{12}$	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{2}{3}$	$\frac{1}{6}$

Simpson's Second Rule.

Ordinates	0	1	2	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{6}$	$6\frac{1}{3}$	$6\frac{1}{2}$	$6\frac{2}{3}$	$6\frac{5}{6}$	7
Multipliers	1	3	3	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	1	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{2}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{6}$
Ordinates	0	$\frac{1}{3}$	$\frac{2}{3}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4
Multipliers	$\frac{1}{3}$	1	1	$\frac{7}{12}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{4}$
Ordinates	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{3}$	$3\frac{2}{3}$	4	$4\frac{1}{6}$	$4\frac{1}{3}$	$4\frac{1}{2}$	$4\frac{2}{3}$	$4\frac{5}{6}$	5
Multipliers	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	1	$1\frac{1}{2}$	$1\frac{1}{2}$	$\frac{5}{6}$	1	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{6}$

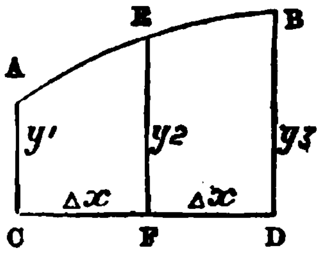
Note.—The ordinates in this table are numbered the same as if they were the number of intervals from the origin.

26. *To calculate the area separately of one of the two divisions of a parabolic figure of the second order.* (Fig. 79.)

RULE.—To eight times the middle ordinate add five times the near end ordinate, and subtract the far end ordinate; multiply the remainder by $\frac{1}{12}$ the common interval: the result will be the area.

Note.—The near end ordinate is the ordinate at the end of the division of which the area is to found.

FIG. 79.

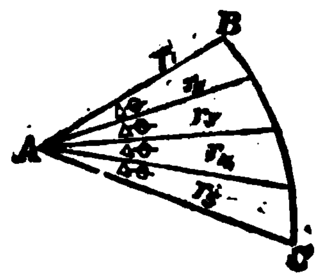


Ex.: In the figure ABCD let it be required to find the area of the division ACEF. Let y_1 = the near end ordinate, y_2 = the middle ordinate, and y_3 = the far end ordinate; then $\int y dx = \frac{\Delta x}{12}(5y_1 + 8y_2 - y_3)$.

27. *To measure an area bounded by an arc of a plane curve and two radii.* (Fig. 80.)

RULE.—Divide the angle subtended by the arc into any number of equal angular intervals by means of radii. Measure these radii and compute their half-squares. Treat those half-

FIG. 80.



squares as if they were ordinates of a curve by Simpson's first or second rule, as the number of intervals may require.

Note.—The common interval must be taken in circular measure. (See pp. 10, 11, & 612.)

Ex.: In the figure ABC let r_1, r_2, r_3, r_4, r_5 = the radii, $\Delta\theta$ = the common angular interval, and $\int \frac{r^2}{2} d\theta$ = the area; then

$$\int \frac{r^2}{2} d\theta = \frac{(r_1^2 + 4r_2^2 + 2r_3^2 + 4r_4^2 + r_5^2)\Delta\theta}{6}.$$

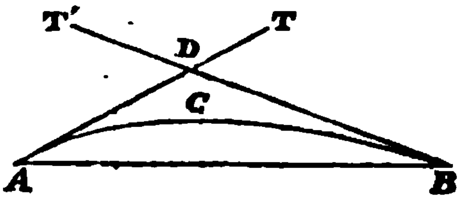
28. *To measure any curved line.* (Fig. 81.)

If the curve is rather irregular, divide it by the eye into any number of circular arcs; join the extremities of each of these arcs by chords. The sum of the length of each of these arcs found by the following rule will be the total length of the curved line.

RULE.—Draw a tangent to the curve at each of its extremities; then take the sum of the two distances from the point of intersection of the two tangets to the extremities of the curve, together with twice the length of the chord; divide the rule by 3 for the length of the arc.

Ex. (fig. 81): Let ACB be one of the arcs, and AB a chord joining the two extremities, and AT, BT′ tangents to the curve at its extremities, cutting each other in D; then the length of the curve

FIG. 81.



$$\text{ACB} = \tfrac{1}{3}(\text{AD} + \text{DB} + 2\text{AB}).$$

29. *To measure any curvilinear area by means of Tchebycheff's rule.*

RULE.—Find the middle point of base, and from it set off, along the base, and in both directions, distances equal to the half length of base multiplied by the constants given in the Schedule below. Erect ordinates at the points so obtained and measure them. Their sum, divided by the number of ordinates, and multiplied by the length of base is the area required.

SCHEDULE.

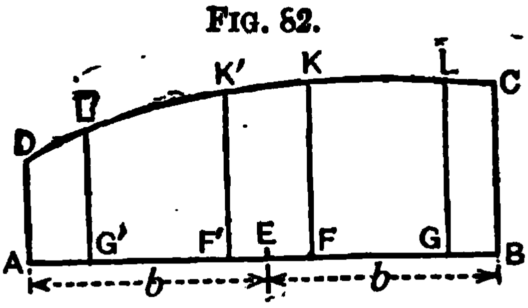
Number of Ordinates used	Distance of Ordinates from Middle of Base in Fractions of Half the Base Length
2	·5773
3	O, ·7071
4	·1876, ·7947
5	O, ·3745, ·8325
6	·2666, ·4225, ·8662
7	O, ·3239, ·5297, ·8839
9	O, ·1679, ·5288, ·6010, ·9116

Note.—As evident from the Schedule, there is an ordinate *at* the middle of base, only when an odd number of ordinates is employed.

Examples.—With *four* ordinates. (Fig. 82.)

Let ABCD be the figure. Bisect the base AB at E. Calling the half length of base b, set off EF and EF′ equal to ·1876 b and EG and EG′ equal to ·7947 b. Erect ordinates GL, FK, F′K′, G′L′ at G, F, F′, G′; and call them y_1, y_2, y_3, and y_4.

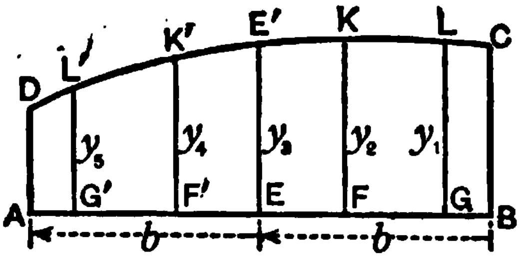
FIG. 82.



Then area of figure ABCD $= \dfrac{y_1 + y_2 + y_3 + y_4}{4} \times 2b.$

With *five* ordinates. (Fig. 83.)

FIG. 83.



As before, let ABCD be the figure, E the middle of base, and b its half-length. Set off EF and EF' equal to ·3745 b and EG and EG' equal to ·8325 b, and erect ordinates at G, F, E, F', and G', calling them y_1, y_2, y_3, y_4, y_5.

$$\text{Then area of figure ABCD} = \frac{y_1 + y_2 + y_3 + y_4 + y_5}{5} \times 2b.$$

Note.—This rule can be used for calculating displacements, and fewer ordinates are required for the same degree of accuracy than if Simpson's Rule is used. It is also of great assistance in preparing cross curves of stability. (*See* page 109.)

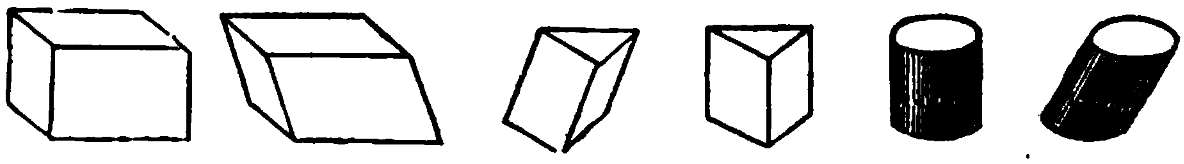
II. MENSURATION OF SOLIDS.

PROBLEMS.

1. *To find the solidity of any parallelopiped, prism, or cylinder.* (Fig. 84.)

RULE.—Multiply the area of the base by the perpendicular height, the result will be the solidity.

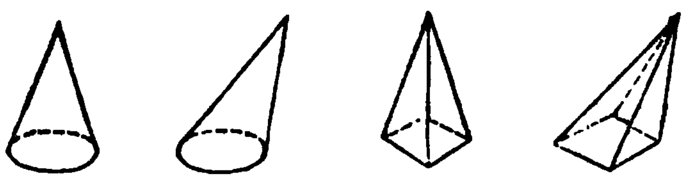
FIG. 84.



2. *To find the solidity of a cone or pyramid.* (Fig. 85.)

RULE.—Multiply the area of the base by $\frac{1}{3}$ the perpendicular height; the product will be the solidity.

FIG. 85.



3. *To find the solidity of the frustum of a cone or pyramid.* (Fig. 86.)

RULE.—To the sum of the areas of the two ends add the square root of their product; this final sum being multiplied by $\frac{1}{3}$ of the perpendicular height will give the solidity.

FIG. 86.

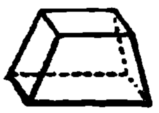
4. *To find the solidity of a wedge.* (Fig. 87.)

FIG. 87.

RULE.—Add the length of the edge to twice the length of the base; multiply the sum by the width of the base and the product by $\frac{1}{6}$ of the perpendicular height: the result will be the solidity.

5. *To find the solidity of a prismoid.* (Fig. 88.)

FIG. 88.



RULE.—To the sum of the areas of the two ends add four times the area of a section parallel to the base and equally distant from both ends; the sum being multiplied by $\frac{1}{6}$ the perpendicular height will give the solidity.

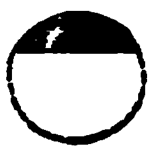
FIG. 89.

6. *To find the solidity of a sphere or globe.* (Fig. 89.)

RULE.—Multiply the cube of the diameter by ·5236; the product will be the solidity.

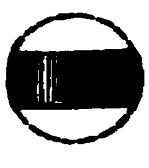
7. *To find the solidity of the segment of a sphere.* (Fig. 90.)

FIG. 90.



RULE.—Add the square of the height to 3 times the square of the radius of the base; that sum multiplied by the height and that product by ·5236 will give the solidity.

FIG. 91.



8. *To find the solidity of a zone of a sphere.* (Fig. 91.)

RULE.—To the sum of the squares of the radii of the two ends add $\frac{1}{3}$ the square of the height; multiply the sum by the height and that result by 1·5708: the result will be the solidity.

9. *To find the solidity of a cylindrical ring.*

RULE.—To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness, and the product by 2·4674: the result will be the solidity.

TABLE TO FIND THE SOLIDITY AND SURFACE OF ANY REGULAR SOLID.

S = solidity. A = area. L = linear edge.
r = radius of inscribed circle.

No. of Sides	Name	$A = L^2 \times$	$S = L^3 \times$	$r = L \times$
4	Tetrahedron .	1·732051	·117851	·204124
6	Hexahedron .	6·000000	1·000000	·500000
8	Octahedron .	3·464102	·471405	·408248
12	Dodecahedron	20·645729	7·663119	1·113516
20	Icosahedron .	8·660254	2·181695	·755750

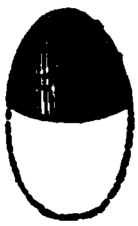
10. *To find the solidity of an ellipsoid.* (Fig. 92.)

FIG. 92.

RULE.—Multiply the fixed axis by the square of the revolving one, and the product by ·5236; the result will be the solidity.

11. *To find the solidity of the segment of an ellipsoid when the base is circular.* (Fig. 93.)

FIG. 93.



RULE.—Take double the height of the segment from three times the length of the fixed axis; multiply the difference by the square of the height, and that product by ·5236: then that result multiplied by the square of the revolving axis and the product divided by the square of the fixed axis will give the solidity.

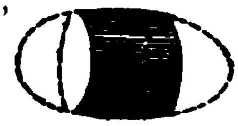
12. *To find the solidity of the segment of an ellipsoid when the base is elliptical.* (Fig. 94.)

FIG. 94.

RULE.—Take double the height of the segment from three times the length of the revolving axis; multiply the difference by the square of the height, and that product by ·5236: then that result multiplied by the fixed axis, and the product divided by the revolving axis, will give the solidity.

13. *To find the solidity of the middle frustum of an ellipsoid when the ends are circular.* (Fig. 95.)

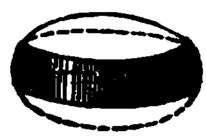
FIG. 95.



RULE.—Multiply the sum of the square of the middle diameter and the square of the diameter of one end by the length of the frustum, and that product by ·5236 for the solidity.

14. *To find the solidity of the middle frustum of an ellipsoid when the ends are elliptical.* (Fig. 96.)

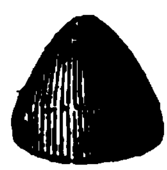
FIG. 96.



RULE.—To twice the product of the transverse and conjugate diameters of the middle section, add the product of the transverse and conjugate diameters of one end; multiply the sum by the height of the frustum, and that product by ·2618: the result will be the solidity.

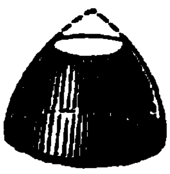
15. *To find the solidity of a paraboloid.* (Fig. 97.)

FIG. 97.



RULE.—Multiply the square of the diameter of the base by the perpendicular height, and the result by ·3927; the product will be the solidity.

FIG. 98.

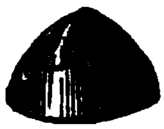


16. *To find the solidity of the frustum of a paraboloid when its ends are perpendicular to its axis.* (Fig. 98.)

RULE.—Multiply the sum of the squares of the diameters of the two ends by the height of the frustum; the product multiplied by ·3927 will be the solidity.

17. *To find the solidity of a hyperboloid.* (Fig. 99.)

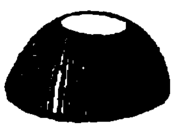
FIG. 99.



RULE.—To the square of the radius of the base add the square of the diameter at the middle between the base and the vertex; this sum multiplied by the altitude, and the product by ·5236, will be the solidity.

18. *To find the solidity of the frustum of a hyperboloid.* (Fig. 100.)

FIG. 100.



RULE.—To the sum of the squares of the semi-diameters of the two ends add the square of the middle diameter; this sum multiplied by the altitude, and the result by ·5236, will be the solidity.

19. *To measure the volume of a solid bounded on one side by a curved surface.*

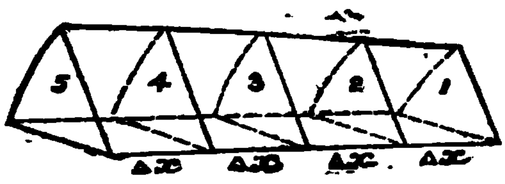
(I.) *To measure the volume in slices.*

RULE.—Take one of the plane surfaces as the base, and divide the mass into slices parallel to that base and sufficiently thin as to be able either to neglect or account separately for the curvature.

Then take the volume of each slice separately, and add them together for the whole volume, taking account of the curvature in this addition if necessary.

(II.) *To measure the volume by the rules applicable to the area of a plane curve.* (Fig. 101.)

FIG. 101.



RULE.—Take a straight line in the figure as a base line, or line of abscissa, and divide the figure along that line into any number of equal parts, and measure the areas of the plane sections at those points of division by the rules applicable to the area of a plane curve.

Then treat the areas thus found as if they were the ordinates

of a plane curve of the same length as the figure, and the result will be the volume of the solid.

Example. (See fig. 101.)

No. of Sections	Areas of Sections	Multipliers	Products
1	5 feet	1	5
2	10 feet	4	40
3	15 feet	2	30
4	20 feet	4	80
5	25 feet	1	25

$$180$$

$$\frac{\Delta x}{3} = 2$$

Area $= 360$ feet

(III.) *To measure the volume by Dr. Woolley's method.* (Fig. 102.)

RULE.—Take a straight line in the figure as a base line, and divide the figure along that line by an odd number of parallel and equidistant planes perpendicular to the base. Then divide the figure horizontally in the same way by a number of plane sections parallel to the base. Then take ordinates at the intersections of the horizontal with the vertical plane sections in their consecutive order, and treat them as follows:—

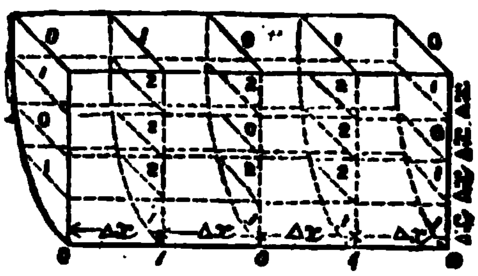
(1) Neglect absolutely all ordinates which are *odd* in *both* planes of section.

(2) Neglecting the outside rows of ordinates, double every ordinate which is *even* in *either* or *both* planes of section, and add them together.

(3) Add to this the simple sum of all the *even* ordinates in the outside rows.

(4) Multiply this final sum by $\frac{2}{3}$ of the product of the common vertical interval, by the common horizontal interval, and the result will be the volume.

FIG. 102.



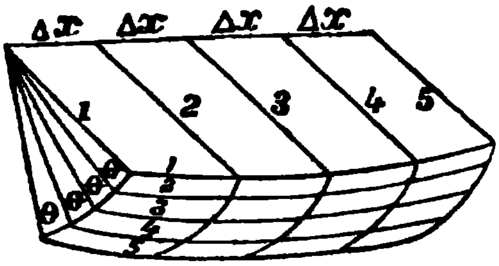
Ex. In the accompanying figure the multiplier for each ordinate is shown above it, so that if S = the sum of the products of the ordinates by their respective multipliers, V = the volume, and $\Delta x'$ = the common vertical interval, and Δx = the common horizontal interval, then

$$V = \frac{2(S \times \Delta x' \times \Delta x)}{3}.$$

20. *To measure the volume of a wedge-shaped solid bounded on one side by a curved surface.* (Fig. 103.)

RULE.—Divide the figure longitudinally by a number of planes radiating from the edge at equal angular intervals, and also divide the length of figure into a number of equal intervals for ordinates, and treat each of the radiating planes as follows:—

FIG. 103.



(I.) Measure the ordinates as if for taking the areas of the several planes, but instead of the ordinates themselves compute their half-squares, and treat them as if they were the ordinates of a plane curve of the same length as the figure. The result of this calculation is called the moment of the radiating plane.

(II.) Treat the moments of the radiating planes as if they were the ordinates of a curve, but taking the common angular interval in circular measure.

Example. (See fig. 103.)

No. of Planes	Moments of the Radiating Planes	Multipliers	Products
1	105	1	105
2	110	4	440
3	115	2	230
4	120	4	480
5	125	1	125

$$\frac{\theta}{3} = \frac{\text{angular interval}}{3} = \cdot 0291$$

$$\begin{array}{r} 1380 \\ \cdot 0291 \\ \hline 1380 \\ 12420 \\ 2760 \\ \hline \text{Volume} = 40 \cdot 1580 \end{array}$$

21. *To find the mean sectional area of a solid.*

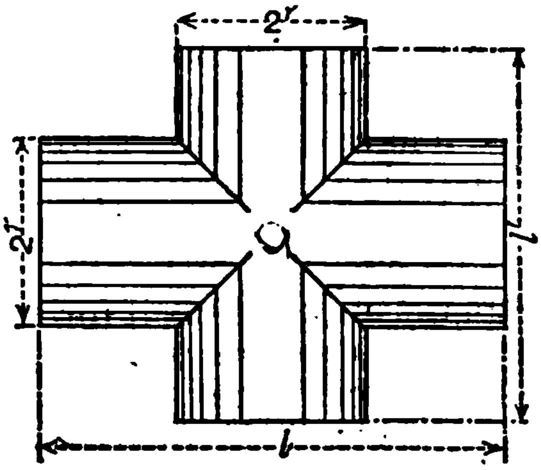
RULE.—Divide the volume of the solid by its length; the result will be the mean sectional area.

22. *To set off the correct form of a mean cross-section.*

RULE.—Divide the figure longitudinally by a number of horizontal planes; take the mean breadth of each of the horizontal planes and set them off perpendicular to a fixed straight line, and at the same height as their corresponding planes in the solid: a line passing through the ends of these mean breadths will be the correct form of the mean sectional area of the solid.

Note.—The mean breadth of a plane curve is found by dividing the area of the curve by its length.

FIG. 103A.



23. *To find the volume of a four-way piece of piping.*

Let r (fig. 103A) be the radius of the piping and l and l' the lengths.

$$\text{Then volume } = \pi r^2\left(l + l' - \frac{2}{3}r\right).$$

III. MENSURATION OF THE SURFACES OF SOLIDS.

PROBLEMS.

1. *To find the slant surface of a cone or pyramid.*

RULE.—Multiply the perimeter of the base by the slant height; half the product will be the convex surface.

2. *To find the convex surface of the frustum of a cone or pyramid.*

RULE.—Multiply the sum of the perimeters of the two ends by the slant height; half the product will be the convex surface.

3. *To find the convex surface of a sphere.*

RULE.—Multiply the circumference by the diameter, or square the diameter and multiply the product by 3·1416; either result will be the convex surface.

4. *To find the convex surface of the segment of a sphere.*

RULE.—Multiply the circumference of the whole sphere by the height of the segment; the product will be the convex surface.

5. *To find the convex surface of the zone of a sphere.*

RULE.—Multiply the circumference of the whole sphere by the height of the zone; the result will be the convex surface.

6. *To find the convex surface of a cylindrical ring.*

RULE.—Multiply the sum of the thickness of the ring and the inner diameter by the thickness of the ring, and that product by 9·8696; the result will be the convex surface.

7. *To find the mean curved girth of the convex surface of an irregular solid.*

RULE.—Divide the figure into an even number of equal parts, and at the points of division measure girths at right angles to the length of the solid; multiply these girths by a proper set of multipliers, applicable to the area of a plane curve; divide the sum of these results by 3, and that quotient by the number of intervals; the last result will be the mean girth.

8. *To find the convex surface of an irregular figure.*

RULE 1.—Multiply the length of the solid by the mean girth.

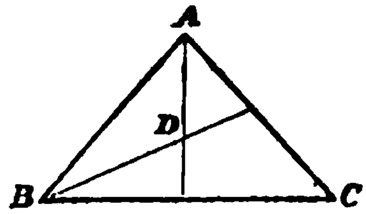
RULE 2.—Measure the curved girths as if for finding the mean girth; treat those girths as if they were ordinates of a plane curve of the same length as the figure; the result will be the curved surface.

CENTRES AND MOMENTS OF FIGURES.

TO FIND THE CENTRES OF A FEW SPECIAL FIGURES.

1. *Triangle.* (Fig. 104.)

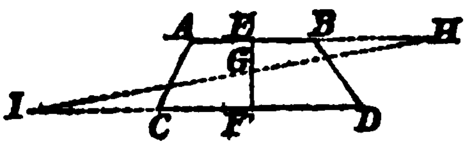
FIG. 104.



RULE.—From the middle points of any two sides draw lines to the opposite angle; the point of intersection D of these lines is the required centre.

2. *Trapezoid.* (Fig. 105.)

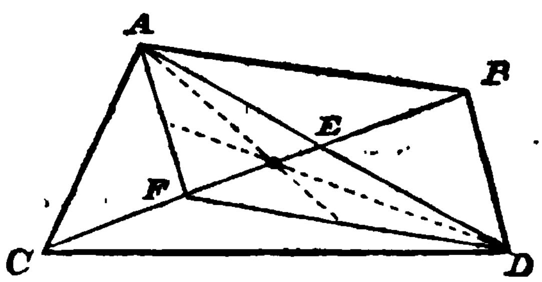
FIG. 105.



RULE.—Bisect AB in E and CD in F and join EF. Produce AB beyond B to H, making $BH = CD$, and produce CD beyond C to I, making $CI = AB$; then join HI, and where this line intersects EF is the centre of gravity G.

3. *Trapezium.* (Fig. 106.)

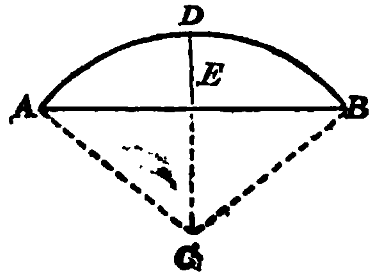
FIG. 106.



RULE.—Draw the diagonals AD and CB intersecting in E; along CB set off CF equal to EB, and join FA and FD; the centre of the triangle AFD will be the centre of the trapezium.

4. *Circular arc.* (Fig. 107.)

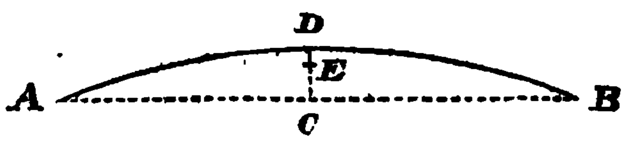
FIG. 107.



RULE.—Let ADB be the circular arc and C the centre of the circle of which it is a part (to find C, see p. 18); bisect the arc AB in D, and join DC and AB; multiply the radius CD by the chord AB, and divide by the length of the arc ADB; lay off the quotient CE upon CD; then E is the centre required.

5. *Very flat curved line* (*approximate*). (Fig. 108.)

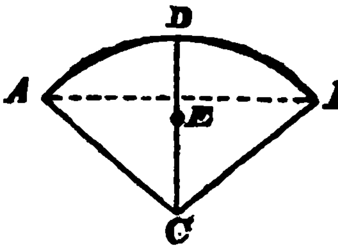
FIG. 108.



RULE.—Let ADB be the arc; draw the chord AB, and bisect it in C; draw CD perpendicular to AB; make CE equal to $\frac{2}{5}$ of CD; then E will be the centre required.

6. *Sector of a circle.* (Fig. 109.)

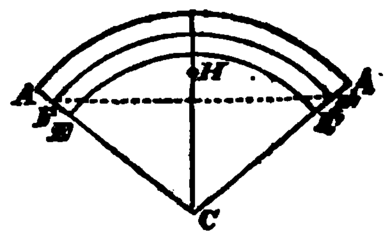
FIG. 109.



RULE.—Let ABC be the sector, E its centre; multiply the chord AB by $\frac{2}{3}$ of the radius CA; divide the product by the length of the arc: the quotient equals the distance CE set along the line CD, D being at the bisection of the arc AB.

7. *Sector of a plane circular ring.* (Fig. 110.)

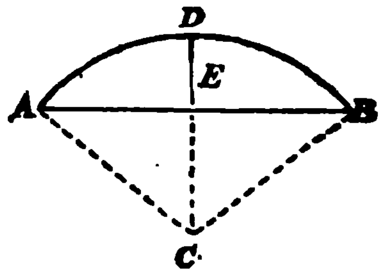
FIG. 110.



RULE.—Let CA be the outer and CE the inner radius of the ring; divide twice the difference of the cubes of the inner and outer radii by three times the difference of their squares; the quotient will be an intermediate radius CF, with which describe the arc FF, subtending the same angle with the sector: the centre H of the circular arc FF, found by Rule 4, will be the centre required.

8. *Circular segment.* (Fig. 111.)

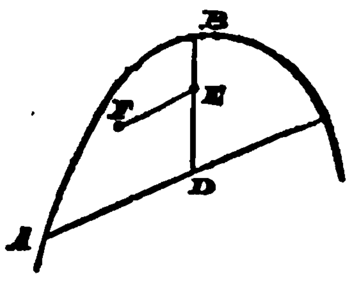
FIG. 111.



RULE.—Let C be the centre of the circle of which it is a part; bisect the arc AB in D, and join CD; divide the cube of half the chord AB by three times the area of half the segment ADB: set off the quotient CE along CD, and E will be the centre required.

9. *Parabolic half-segment.* (Fig. 112.)

FIG. 112.



RULE.—Let ABD be a half-segment of a parabola, BD being part of a diameter parallel to the axis and AD an ordinate conjugate to that diameter—that is, parallel to a tangent at B. Make BE equal to $\frac{2}{5}$ BD, and draw EF parallel to AD and equal to $\frac{3}{8}$ AD. Then F will be the centre of the half-segment.

10. *Height of centre of semicircle from its base.*

RULE.—Multiply the radius of the semicircle by 4, and divide the product by 3π.

11. *Height of centre of parabola from its base.*

RULE.—Multiply its vertical height by 2, and divide the product by 5.

12. *Height of centre of elliptic segment from the lesser diameter of the ellipse of which it is a part.*

RULE.—Take the square of half the greater diameter of the ellipse, and divide the product by the square of half the lesser diameter; multiply that result by the cube of half the length of the base of the segment, and divide the result by three times its half-area.

Ex.: Let D = greater diameter of ellipse, and d = lesser diam.
B = base of segment, and A = area of segment.
H = height of centre from lesser diameter of ellipse.

$$H = \frac{\left(\frac{D}{2}\right)^2 \times \left(\frac{B}{2}\right)^2}{\left(\frac{d}{2}\right)^2 \times \frac{3A}{2}}$$

13. *Prism or cylinder with plane parallel ends.*

RULE.—Find the centres of the ends; a straight line joining them will be the axis of the prism or cylinder, and the middle point of that line will be the centre required.

14. *Cone or pyramid.*

RULE.—Find the centre of the base, from which draw a line to the summit; this will be the axis of the cone or pyramid, and the point at $\frac{1}{4}$ from the base along that line will be the centre.

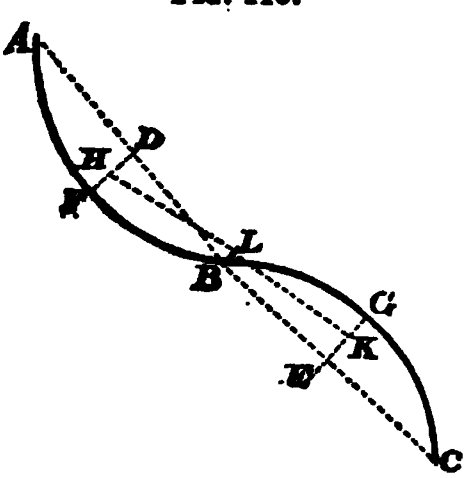
15. *Hemisphere or hemi-ellipsoid.*

RULE.—The distance of the centre from the circular or elliptic base is $\frac{3}{8}$ of the radius of the sphere, or of that semi-axis of the ellipsoid which is perpendicular to the base.

16. *Paraboloid.*

RULE.—The distance of its centre from the base along its axis is $\frac{1}{3}$ of the height from the base.

FIG. 113.



17. *To find the centre of gravity of any continuous curved line.* (Fig. 113.)

Ex.: Let ABC be the given curve; bisect it at B; join AB and BC, and bisect those chords at the points D and E respectively; set off FD perpendicular to AB, and EG perpendicular to BC; make FH = $\frac{2}{3}$DF and GK = $\frac{2}{3}$GE, and join HK; bisect HK at the point L, which will be a close approximation to the position of the centre of gravity of the curved line ABC.

RULES FOR FINDING THE MOMENTS AND CENTRES OF FIGURES.

The geometrical moment of a figure, whether a line, an area, or a solid, relatively to a given plane or axis is the product of the magnitude of that figure, into the perpendicular distance of its centre from the given plane or axis, and is equal to the sum of the moments of all its parts relatively to the same plane.

The centre of an area is determined when its distance from two axes in the plane of the figure is known.

The centre of a figure of three dimensions is determined

when its distance from three planes not parallel to one another is known.

1. *To find the moment of an irregular figure relatively to a given plane or axis.*

RULE.—Divide the figure into parts whose centres are known; multiply the magnitude of each of its parts into the perpendicular distance of its centre from the given plane or axis; distinguish the moments into positive and negative, according as the centres of the parts lie to one side or the other of the plane: the difference of the two sums will be the resultant moment of the figure relatively to the given plane or axis, and is to be regarded as positive or negative, according as the sum of the positive or negative moments is the greater.

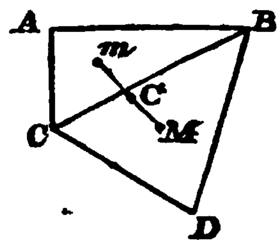
2. *To find the perpendicular distance of the centre of an irregular figure from a given plane or axis.*

RULE.—Divide the moment of that figure relatively to the given plane or axis by its magnitude; the quotient will be the perpendicular distance of its centre from the given plane or axis.

3. *To find the centre of a figure consisting of two parts whose centres are known.* (Fig. 114.)

RULE.—Multiply the distance between the two known centres by the magnitude of either of the parts, and divide the product by the magnitude of the whole figure; the quotient will be the distance of the centre of the whole figure from the centre of the other part, the centre of the whole figure being in the straight line joining the centres of the two parts.

FIG. 114.

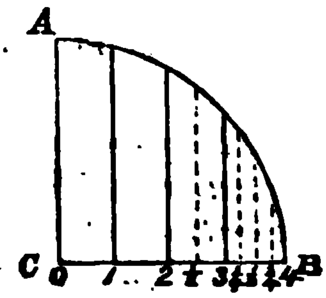


Ex.: Let ABCD be such a figure, M and m the magnitude of its two respective parts, $M+m$ the magnitude of the whole figure, D the distance between the centres M and m of the two parts, and C the centre of the whole figure.

$$MC = \frac{m \times D}{M+m} \qquad mC = \frac{M \times D}{M+m}.$$

4. *To find the centre of any plane area by means of ordinates.* (Fig. 115.)

FIG. 115.



Let ABC, the quadrant of a circle, be such an area; CB the base line, divided into a number of equal parts by ordinates; AC the transverse axis traversing its origin.

1*st.* *Determine the perpendicular distance of the centre of the quadrant from the transverse axis in the following manner:—*

RULE.—Multiply each ordinate by its distance from the transverse axis; consider the products as ordinates of a new curve of the same length as the given figure: the area of that curve, found by the proper rule, will be the moment of the figure relatively to the transverse

axis; this moment, divided by the whole area of the figure, will give the perpendicular distance of its centre from the transverse axis.

In algebraical symbols the moment of a plane figure relatively to its transverse axis, and found by the above rule, is expressed thus:—

$$\int xy\,dx.$$

Note.—In practice it is better to proceed as follows:—Multiply the ordinates first by their multipliers, and then those products by the number of intervals from the origin; take the sum of those products and multiply it by $\frac{1}{3}$rd of a whole interval squared, if Simpson's first rule is used, by $\frac{3}{8}$ths of a whole interval squared, if Simpson's second rule is used, and so on for the other rules.

Example.

No. of Intervals	Ordinates	Multipliers	Products	Products × No. of Intervals from Origin
0	16·0000	1	16·0000	·00000
1	15·4919	4	61·9676	61·9676
2	13·8564	$1\frac{1}{2}$	20·7846	41·5692
$2\frac{1}{2}$	12·4900	2	24·9800	62·4500
3	10·5830	$\frac{3}{4}$	7·93725	23·81175
$3\frac{1}{4}$	9·3274	1	9·3274	30·31405
$3\frac{1}{2}$	7·7460	$\frac{1}{2}$	3·8730	13·5555
$3\frac{3}{4}$	5·5678	1	5·5678	20·87925
4	0·0000	$\frac{1}{4}$	0·0000	·00000
		$\frac{\text{Interval}}{3} =$	150·43765 / $\frac{4}{3}$	$\frac{\text{Interval}^2}{3} =$ 254·54735 / $\frac{16}{3}$
		Approximate area =	200·58353	Approx. moment = 1357·585

$$\frac{\text{Moment } 1357\cdot585}{\text{Area } 200\cdot5835} = 6\cdot768 \left\{ \begin{array}{l} \text{approximate perpendicular distance} \\ \text{of centre from the transverse axis.} \end{array} \right.$$

2nd. Find the perpendicular distance of its centre from the base line.

RULE.—Square each ordinate, and take the half-squares as ordinates for a new curve of the same length as the figure; the area of that curve, found by the proper rule, will be the moment of the figure relatively to the base line: this moment, divided by the whole area of the figure, will give the perpendicular distance of its centre from the base line.

In algebraical symbols the moment of a plane figure relatively to its base line, found by the above rule, is expressed thus:—

$$\int \frac{y^2}{2}\,dx.$$

Example.

No. of Intervals	Ordinates	Half-squares	Multipliers	Products
0	16·0000	128·0000	1	128·0000
1	15·4919	119·9995	4	479·9980
2	13·8564	95·9999	2	191·9998
3	10·5830	55·9999	4	223·9996
4	0·0000	0·0000	1	0·0000
				1023·9974
			$\frac{\text{Interval}}{3}$ =	$\frac{4}{3}$
			Approximate moment =	1365·3298

$$\frac{\text{Moment } 1365{\cdot}3298}{\text{Area } 201{\cdot}0624} = 6{\cdot}796 \left\{ \begin{array}{l}\text{approximate perpendicular dis-}\\ \text{tance of centre from base.}\end{array}\right.$$

$$\frac{\text{Actual moment} = 1365{\cdot}3}{\text{Actual area} = 201{\cdot}0624}$$

5. *To find the centre of a plane area bounded by a curve and two radii by means of polar co-ordinates.* (See fig. 82.)

1*st. Determine the perpendicular distance of its centre from a plane traversing the pole and at right angles to one of the bounding radii, called the first radius, in the following manner:—*

RULE.—Divide the angle subtended by the arc into a convenient number of equiangular intervals by means of radii; measure the lengths of the radii from the pole to the arc, and multiply the third part of the cube of each of them by the cosine of the angle which they respectively make with the first radius; treat these products by one of the rules applicable to finding the area of a plane curve (the only difference being that the common interval is taken in circular measure); the result will be the moment of the figure relatively to the plane traversing the pole: this moment, divided by the area of the figure, will give the perpendicular distance of its centre from the plane traversing the pole.

Example.

No. of Radii	Radii	$\frac{\text{Cubes of Radii}}{3}$	Angles with First Radius	Cosines	Products	Simpson's Multipliers	Products
1	12	576	0°	1·0000	576·0000	1	576·0000
2	12	576	5°	·9962	573·8112	4	2295·2448
3	12	576	10°	·9848	567·2448	2	1134·4896
4	12	576	15°	·9659	556·3584	4	2225·4336
5	12	576	20°	·9397	541·2672	1	541·2672
							6772·4352

$$\frac{\text{Interval in circular measure}}{3} = {\cdot}0291$$

Moment relatively to plane traversing pole = 197·077864

$$\frac{\text{Moment } 197 \cdot 077864}{\text{Area } 25 \cdot 1327} = 7 \cdot 841 \left\{ \begin{array}{l} \text{perpendicular distance of centre} \\ \text{from plane traversing pole.} \end{array} \right.$$

In algebraical symbols the moment, as here found, is expressed thus:—

$$\int \frac{r^3}{3} \cos \theta d\theta.$$

2nd. Determine the moment of the figure relatively to the first radius precisely in the same way as in the foregoing rule, with the exception that sines must be used in the place of cosines; this moment, divided by the area of the figure, will give the perpendicular distance of its centre from the first radius.

Note.—It is usual, in practice, to defer the division of the cubes of the radii by 3 until after the addition of the products.

Example.

No. of Radii	Radii	Cubes of Radii / 3	Angles with First Radius	Sines of Angles	Products	Simpson's Multipliers	Products
1	12	576	0°	·0000	·0000	1	·0000
2	12	576	5°	·0872	50·2272	4	200·9088
3	12	576	10°	·1736	99·9936	2	199·9972
4	12	576	15°	·2588	149·0688	4	596·2752
5	12	576	20°	·3420	196·9920	1	196·9920
							1194·1732
					Interval in circular measure / 3 =		·0291
					Moment relatively to first radius =		34·750440

$$\frac{\text{Moment } 34 \cdot 75044}{\text{Area } 25 \cdot 1327} = 1 \cdot 38 \left\{ \begin{array}{l} \text{perpendicular distance of centre from} \\ \text{first radius.} \end{array} \right.$$

In algebraical symbols the moment as here found is expressed thus:—

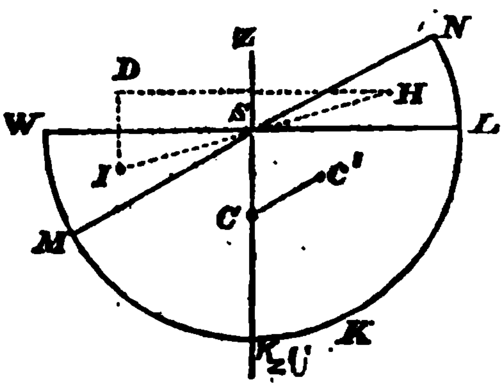
$$\int \frac{r^3}{3} \sin \theta d\theta.$$

6. *To find the perpendicular distance of the centre of a solid, bounded on one side by a curved surface* (figs. 101 and 102), *from a plane perpendicular to a given axis at a given point.*

RULE.—Proceed as in Rule 4, p. 54, to find the moment relatively to the plane, substituting sectional areas for breadths; then divide the moment by the volume (as found by Rule 2, p. 47): the quotient will be the required distance. To determine the centre completely, find its distance from three planes no two of which are parallel.

7. *Having the moment and centre of a figure relatively to a given plane, to find the new moment and centre of the figure relatively to the same plane when a part of the figure is shifted.* (Fig. 116.)

FIG. 116.



In the figure WLK let C be its centre, and ZZ′ a plane with respect to which the moment of the figure is known; suppose the part WSM to be transferred to the new position SNL, so as to alter the shape of the figure from WLK to MNK; let I be the original and H the new centre of the shifted part: then *the moment of the figure* MNK *relatively to the plane* ZZ′ *is found as follows*:—

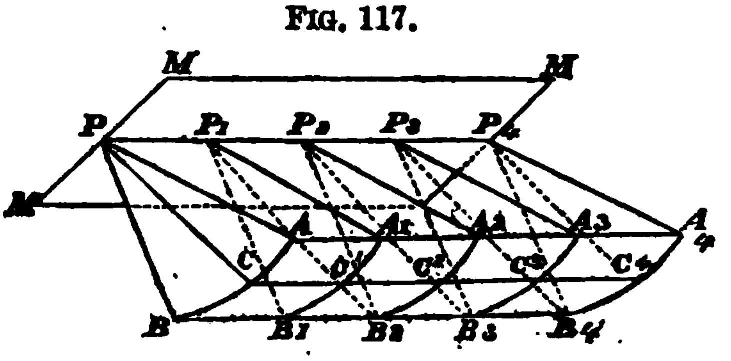
RULE.—Measure the distance, perpendicular to the plane of moments, between the centres of the original and new position of the shifted part, as HD, and multiply it by the magnitude of the shifted part; the product will be the moment required. *The new position of the entire figure is then found by the following rule*:—

RULE.—Multiply the distance between the centres of the original and new position of the shifted part by the magnitude of that part; that product, divided by the magnitude of the whole figure, will give the distance the centre has traversed in the direction in which the part has been shifted, and in a plane parallel to a line joining the centres of the original and new position of the shifted part, as from C to C′ in fig. 116.

8. *To find the centre of a wedge-shaped solid* (fig. 117) *by means of polar co-ordinates.*

1st. *Determine the perpendicular distance of its centre relatively to a transverse sectional plane, as* PAB.

FIG. 117.



RULE.—Divide the solid by a number of parallel and equidistant planes, as PAB, $P_1A_1B_1$, $P_2A_2B_2$, &c.; then multiply each sectional area by its distance from the plane PAB; treat the products as though they were the ordinates of a curve of the same length as the figure; the area of that curve, found by the proper rule, will be the moment of the figure relatively to the plane PAB: that moment, divided by the volume of the figure, will be the distance required.

2nd. Determine the perpendicular distance of its centre relatively to a longitudinal plane passing through its edge, as MPM, *perpendicular to the first radius*, PB.

RULE.—Divide the figure by a number of longitudinal planes radiating from the edge MPM at equiangular intervals (as PP_4AA_4, PP_4CC_4, PP_4BB_4); also divide the length of the figure into a number of equal intervals by ordinates, and treat each of the longitudinal planes as follows:—Measure its ordinates, take the third part of their cubes, and treat those quantities as if they were ordinates of a new curve; that is, find its area by one of Simpson's rules: the area of that new curve is termed the moment of inertia of the longitudinal plane in question. Then multiply each moment of inertia of the several planes by the cosine of the angle made by the plane to which it belongs with the plane PB, and treat these products by a proper set of Simpson's multipliers; add together the products, and multiply the sum by $\frac{1}{3}$ of the common angular interval in circular measure if Simpson's first rule is used, and by $\frac{3}{8}$ if Simpson's second rule is used. The result will be the moment of the figure relatively to the plane MPM. This moment, divided by the volume of the figure, will be the distance required.

The algebraical expression for the moment as found in this rule is

$$\iint \frac{r^3}{3} \cos \theta dx d\theta.$$

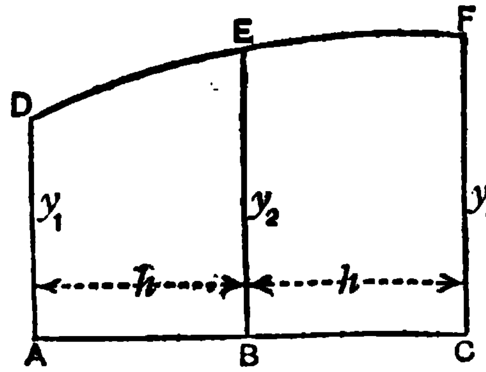
3rd. Determine the perpendicular distance of its centre relatively to a longitudinal plane passing through its edge, and a radius as PP^4BB^4, *by the foregoing rule, with the exception of multiplying by sines instead of cosines.*

Note.—In practice it is usual to defer the division of the cubes of the radii by 3 until after the addition of the products.

9. *To find the centre of gravity of a plane area contained between two consecutive ordinates, with respect to the near end ordinate.*

RULE.—To the sum of three times the near end ordinate, and ten times the middle ordinate, subtract the far end ordinate, and multiply the remainder by the square of the common interval. The product, divided by 24, will be the moment about the near end ordinate.

FIG. 117A.



Ex.: In fig. 117A let ABC be the base, and AD, BE, and CF the ordinates. Call them y_1, y_2, and y_3 respectively, and let the common interval be denoted by h. Then the moment of the area ABED about the

near end ordinate AD is equal to $\frac{(3y_1+10y_2-y_3)\times h^2}{24}$. If this be divided by the area of ABED (see p. 42), the quotient will be the distance of the C.G. from AD.

For an example, let the ordinates be 6·2, 8·5, and 9·4 feet, and the common interval 12 feet.

No. of Ordinates	Ordinates	Multipliers for Area	Products	Ordinates	Multipliers for Moments	Products
1	6·2	5	31·0	6·2	3	18·6
2	8·5	8	68·0	8·5	10	85·0
3	9·4	−1	−9·4	9·4	−1	−9·4
			89·6			94·2
		$\frac{\text{(Interval)}}{12}=$	1		$\frac{\text{(Interval)}^2}{24}=$	6
Area of portion included between 1 and 2			=89·6	Moment about 1=565·2		

$\frac{\text{Moment}\ \ 565\cdot2}{\text{Area}\ \ \ \ 89\cdot6}=6\cdot308$ { Perpendicular distance of centre of portion included between Nos. 1 and 2, from No. 1 ordinate.

Note.—This rule can be used for volumes, similarly as for areas, but it is not usually employed on displacement sheets, owing to the new constants it necessitates. By applying Simpson's first rule to two intervals, and his second to three, and subtracting, the volume and moment of any single interval can be calculated.

Moments of Inertia and Radii of Gyration.

1. *To find the moment of inertia of a body about a given axis.*

Rule.—Conceive the body to be divided into an indefinitely great number of small parts; multiply the mass (or weight) of each of these small parts into the square of its perpendicular distance from the given axis: the sum of all these products as obtained will be the moment of the body about the given axis.

2. *To find the square of the radius of gyration of a body about a given axis.*

Rule.—Divide the moment of inertia of the body relatively to the given axis by the mass (or weight) of the body.

3. *Given the moment of inertia of a body about an axis traversing its centre of gravity in a given direction, to find its moment of inertia about another axis parallel to the first.*

Rule.—Multiply the mass (or weight) of the body by the square of the perpendicular distance between the two axes, and to the product add the given moment of inertia.

4. *Given the separate moments of inertia of a set of bodies about parallel axes traversing their several centres of gravity, to find the moment of inertia of these bodies about a common axis parallel to their separate axes.*

Rule.—Multiply the mass (or weight) of each body by the square of the perpendicular distance of its centre of gravity from the common axis; the sum of all these products, together with all the separate moments of inertia, will be the combined moment of inertia.

5. *Given the square of the radius of gyration of a body about an axis traversing its centre in a given direction, to find the square of the radius of gyration about another axis parallel to the first.*

Rule.—Square the perpendicular distance between the two axes, and add the product to the given square of the radius of gyration.

6. *To find the moment of inertia of a plane area, bounded on one side by a curve* (see fig. 115), *relatively to its base line.*

Rule.—Divide the base line into a suitable number of equal intervals, and measure ordinates at the points of division; take the third part of the cube of each of these ordinates, and treat those quantities so computed as the ordinates of a new curve: the area of that new curve, found by the proper rule, will be the moment of inertia required. In algebraical symbols the above rule is expressed thus:—

$$\int \frac{y^3}{3} dx.$$

Note.—When the moment of inertia is required as a whole, and not in separate parts, it is usual to postpone the division of the cubes till the end of the calculation.

7. *To find the moment of inertia of a plane area, bounded on one side by a curve, relatively to one of its ordinates.*

Rule.—Multiply each ordinate by its proper multiplier, according to one of the rules for finding the area of such figures; then multiply each of the products by the square of the number of whole intervals that the ordinate in question is distant from the

ordinate taken as the axis of moments: the sum of these products, multiplied by $\frac{1}{3}$ or $\frac{3}{8}$ the cube of a whole interval, according as Simpson's first or second rule is used, will be the moment of inertia required.

In algebraical symbols this rule is expressed thus:—

$$\int x^2 y dx.$$

Example I.

CALCULATION OF MOMENT OF INERTIA OF THE QUADRANT OF A CIRCLE RELATIVELY TO THE BASE LINE.

No. of Intervals	Ordinates	$\frac{\text{Cubes of Ordinates}}{3}$	Multipliers	Products
0	16·00	1365·33	1	1365·33
1	15·49	1238·89	4	4955·56
2	13·86	887·50	$1\frac{1}{2}$	1331·25
$2\frac{1}{2}$	12·49	649·48	2	1298·96
3	10·58	394·76	$\frac{3}{4}$	296·07
$3\frac{1}{4}$	9·33	270·72	1	270·72
$3\frac{1}{2}$	7·75	155·16	$\frac{1}{2}$	77·58
$3\frac{3}{4}$	5·57	57·29	1	57·29
4	0·00	0·00	$\frac{1}{4}$	0·00
				9652·76
			$\frac{\text{Interval}}{3}=$	$\frac{4}{3}$
				12870·34

Example II.

CALCULATION OF THE MOMENT OF INERTIA OF THE QUADRANT OF A CIRCLE RELATIVELY TO THE ENDMOST ORDINATE.

No. of Intervals	Ordinates	Multipliers	Products	Squares of Nos. of Intervals	Products
0	16·0000	1	16·0000	0·00	000
1	15·4919	4	61·9676	1·00	61·9679
2	13·8564	$1\frac{1}{2}$	20·7846	4·00	83·1384
$2\frac{1}{2}$	12·4900	2	24·9800	6·25	156·1250
3	10·5830	$\frac{3}{4}$	7·93725	9·00	71·4353
$3\frac{1}{4}$	9·3274	1	9·3274	10·5625	98·5207
$3\frac{1}{2}$	7·7460	$\frac{1}{2}$	3·8730	12·2500	47·4443
$3\frac{3}{4}$	5·5678	1	5·5678	14·0625	78·2972
4	0·0000	$\frac{1}{4}$	0·0000	16·0000	0·0000
					596·9288
				$\frac{\text{Interval}^3}{3}=$	$\frac{64}{3}$

Approximate moment of inertia = 12734·4810

Table of Squares of Radii of Gyration of a few Special Figures.

Body	Axis	Radius² =
1. Rectangle; sides a and b	side a	$\frac{b^2}{3}$
2. Triangle; sides a, b, c, heights a', b', c'	side a	$\frac{a'^2}{6}$
3. Circle or ellipse; diameters a, b	diameter a	$\frac{b^2}{16}$
4. Common parabola; height a, base b	base b	$\frac{8a^2}{35}$
5. Sphere; radius r	diameter	$\frac{2r^2}{5}$
6. Spheroid of revolution; polar semi-axis a, equatorial radius r	polar axis	$\frac{2r^2}{5}$
7. Ellipsoid; semi-axes a, b, c	axis $2a$	$\frac{b^2+c^2}{5}$
8. Spherical shell; external radius r, internal radius r'	diameter	$\frac{2(r^5-r'^5)}{5(r^3-r'^3)}$
9. Circular cylinder; length $2a$, radius r	longitudinal axis $2a$	$\frac{r^2}{2}$
10. Circular cylinder; length $2a$, radius r	transverse diameter	$\frac{r^2}{4}+\frac{a^2}{3}$
11. Hollow circular cylinder; length $2a$, external radius r, internal radius r'	longitudinal axis $2a$	$\frac{r^2+r'^2}{2}$
12. Hollow circular cylinder; length $2a$, external radius r, internal radius r'	transverse diameter	$\frac{r^2+r'^2}{4}+\frac{a^2}{3}$
13. Elliptic cylinder; length $2a$, transverse semi-axes b, c	longitudinal axis $2a$	$\frac{b^2+c^2}{4}$
14. Elliptic cylinder; length $2a$, transverse semi-axes b, c	transverse axis $2b$	$\frac{c^2}{4}+\frac{a^2}{3}$
15. Rectangular prism; dimensions $2a, 2b, 2c$	axis $2a$	$\frac{b^2+c^2}{3}$
16. Rhombic prism; length $2a$, diagonals $2b, 2c$	axis $2a$	$\frac{b^2+c^2}{6}$
17. Rhombic prism; length $2a$, diagonals $2b, 2c$	diagonal $2b$	$\frac{c^2}{6}+\frac{a^2}{3}$

Moment of inertia = square of radius of gyration × the mass (or weight) of the figure.

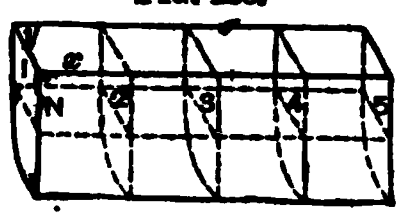
ALGEBRAICAL EXPRESSIONS FOR AREAS, MOMENTS, ETC., BY SIMPSON'S RULES.

Description of Figure.	*Algebraical Expression.*
Plane area	$\int y\,dx$
Plane area by Polar Co-ordinates	$\int \frac{r^2}{2} d\theta$
Solid by ordinary rule	$\int\int z\,dy\,dx$
Wedge solid by Polar Co-ordinates	$\int\int \frac{r^2}{2} dx\,d\theta$
Moment of plane area about longitudinal axis	$\int \frac{y^2}{2} dx$
ditto by Polar Co-ordinates about plane traversing the pole	$\int \frac{r^3}{3} \cos\theta\,d\theta$
Moment of plane area about transverse axis	$\int xy\,d$
ditto by Polar Co-ordinates relatively to the first radius	$\int \frac{r^3}{3} \sin\theta\,d\theta$
Moment of solid wedge about longitudinal plane through its edge and perpendicular to first radius	$\int\int \frac{r^3}{3} \cos\theta\,dx\,d\theta$
Moment of solid wedge about longitudinal plane through first radius	$\int\int \frac{r^3}{3} \sin\theta\,dx\,d\theta$
Moment of inertia of plane area about longitudinal axis	$\int \frac{y^3}{3} dx$
Moment of inertia of plane area about transverse axis	$\int x^2 y\,dx$
Moment of inertia of solid about plane through centre of gravity	$\int\int\int r^2 dx\,dy\,dz$

To find displacement of vessel.

Find area of vertical sections 1, 2, 3, 4, 5 (fig. 118) by Simpson's Rule (see pp. 37, 38) Areas $= \int y\,dz$, $\int y_1 dz$, &c.

FIG. 118.



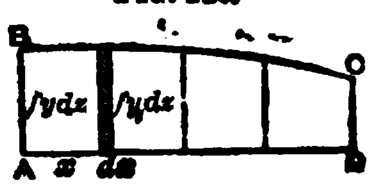
Set off these areas as ordinates to a new curve ABCD and find area as before (fig. 119)

$$= \int\int y\,dz\,dx,$$

which = displacement of vessel.

For method of applying this formula see pp. 78 and 85.

FIG. 119.



To find centre of buoyancy in longitudinal direction.

Find moment of curve ABCD (fig. 120) about AB and divide by area of ABCD. This is done as follows:

Consider a very small section at distance x from A; its area $= \int y_1\, dz\, dx$, and its moment $= \int xy_1 dz\, dx$.

Summing all these terms for total moment we get $\int\int xy\, dz\, dx$,

and $\therefore$ centre of buoyancy from AB $= \int\int \frac{xy\, dz\, dx}{\text{area ABCD}}$.

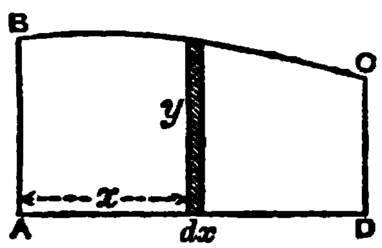
The position of centre of buoyancy below LWL *is found in a similar manner.*

For method of applying this formula see page 85.

To find area and centre of gravity of plane curve. (Fig. 120.)

Let ABCD be such a curve; and consider a small strip whose ordinate is y at a distance x from AB.

FIG. 120.



Then area of this strip $= y\, dx$.

$\therefore$ by integrating area of whole figure $= \int y dx$. CG = centre of gravity.

For CG about AB.

Moment of $y\, dx = x\, y\, dx$.

$\therefore$ moment of whole area $= \int x\, y\, dx$ and CG from AB

$$= \int \frac{x\, y\, dx}{\text{area ABCD}}.$$

For CG about AD.

Area of strip $= y\, dx$. CG of strip is $\frac{y}{2}$ from AD.

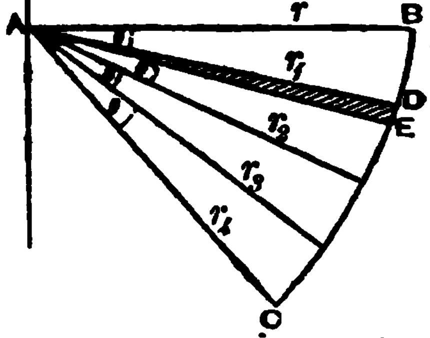
$\therefore$ moment $= \frac{y}{2} y\, dx = \frac{y^2}{2} dx$ and $\therefore$ CG from AB $= \dfrac{\int \frac{y^2}{2} dx}{\text{area ABCD}}$

For method of applying these formulæ see p. 54.

To find area and centre of gravity (CG) *of plane area bounded by a curve and two radii.* (Fig. 121.)

Consider a very small wedge ADE, whose vertical angle $= d\theta$; then DE $= r_1 d\theta$ and area of ADE $= \frac{r_1}{2} r_1 d\theta$ $= \frac{r_1^2}{2} d\theta$ $\therefore$ by integrating whole area $= \int \frac{r^2}{2} d\theta$.

FIG. 121.



Position of CG relative to AB, one of the bounding radii.

Area of ADE $= \frac{r_1^2}{2} d\theta$, and CG $= \frac{2r_1}{3}$ from A $\therefore$ CG from AB $= \frac{2r_1}{3}$ $\sin\theta$ and moment of ADE about AB $= \frac{r_1^2}{2} d\theta \times \frac{2}{3} r' \sin\theta = \frac{r_1^3}{3} \sin\theta \, d\theta$ and moment of ABC $= \int \frac{r^3}{3} \sin\theta \, d\theta$.

$$\therefore \text{CG from AB} = \frac{\int \frac{r^3}{3} \sin\theta \, d\theta}{\text{area ABC}}.$$

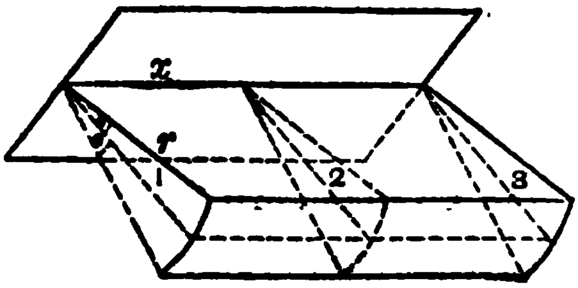
The position of CG relative to AG perpendicular to AB is found in a similar manner and is $= \dfrac{\int \frac{r^3}{3} \cos\theta \, d\theta}{\text{area ABC}}$.

For method of applying these formulæ see p. 56.

To find volume and position of centre of gravity (CG) *of wedge-shaped solid.* (Fig. 122.)

Find area of vertical sections 1, 2, 3 $= \int \frac{r^2}{2} d\theta$, $\int \frac{r_1^2}{2} d\theta$, &c. (fig. 122).

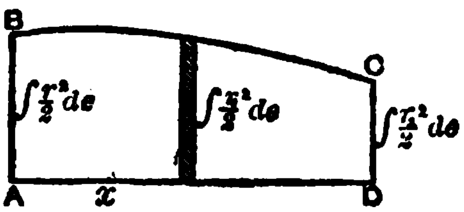
FIG. 122.



Set off these areas as ordinates to a new curve ABCD (fig. 123) and find its area $= \iint \frac{r^2}{2} dx \, d\theta$.

$\therefore$ volume of solid $= \iint \frac{r^2}{2} dx \, d\theta$.

FIG. 123.



To find CG relative to end section find CG from AB (fig. 123); consider a very small section whose ordinate is $\int \frac{r_1^2}{2} d\theta$ at a distance x from AB its area $= \int \frac{r_1^2}{2} d\theta \, dx$ and its moment $= \int x \frac{r_1^2}{2} d\theta \, dx$.

$\therefore$ moment of whole area $= \iint x \frac{r^2}{2} dx\, d\theta$ and CG from AB

$$= \frac{\iint x \frac{r^2}{2}\, dx\, d\theta}{\text{area ABCD}}.$$

To find centre of gravity (CG) *relative to a plane through its edge perpendicular to one of the boundary radii.* (Figs. 122 and 123.)

Find moment of each vertical section relative to the plane $= \int \frac{r^3}{3} \cos\theta\, d\theta$, and set off a curve with these areas as ordinates.

Find area of this curve $= \iint \frac{r^3}{3} \cos\theta\, d\theta\, dx$.

$$\therefore \text{CG from plane} = \frac{\iint \frac{r^3}{3} \cos\theta\, dx\, d\theta}{\text{volume of wedge}}.$$

$$\text{Similarly CG from bounding radial plane} = \frac{\iint \frac{r^3}{3} \sin\theta\, dx\, d\theta}{\text{volume of wedge}}.$$

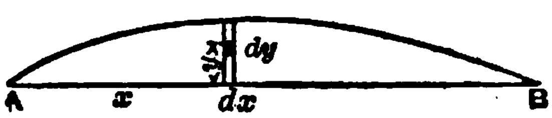
For method of applying these formulæ see p. 58.

To find moment of inertia of a plane area bounded by a curve and a straight line.

Moment of inertia relative to base line (fig. 124).

Consider a very small section whose area $= dx\, dy$ distant from AB $= y$; then its moment of inertia $= y^2\, dx\, dy$ and moment of inertia of whole figure $= \iint y^2\, dx\, dy$

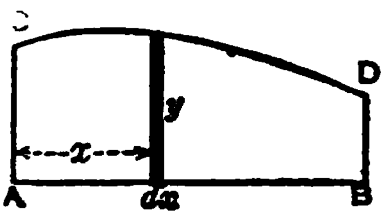
FIG. 124.



$$= \int \frac{y^3}{3}\, dx.$$

Moment of inertia relative to end most ordinate (fig. 125).

FIG. 125.



Consider a very small section whose ordinate is y distant x from AC; its area $= y\, dx$ and its moment of inertia $= x^2\, y\, dx$.

$\therefore$ moment of inertia of whole figure

$$= \int x^2\, y\, dx.$$

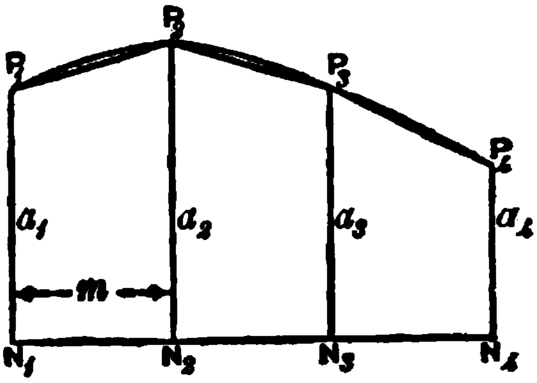
For method of using these formulæ see p. 61.

PROOF OF RULES FOR AREAS BY APPROXIMATE METHODS.

Trapezoidal Rule. (Fig. 126.)

Let $P_1P_4N_4N_1$ be area of figure, $a_1a_2a_3a_4$ the ordinates, and m the common interval. Join P_1P_2, P_2P_3, P_3P_4.

FIG. 126.



Area of trapezium

$$P_1N_2 = m\left(\frac{a_1 + a_2}{2}\right)$$

,, ,, $$P_2N_3 = m\left(\frac{a_2 + a_3}{2}\right)$$

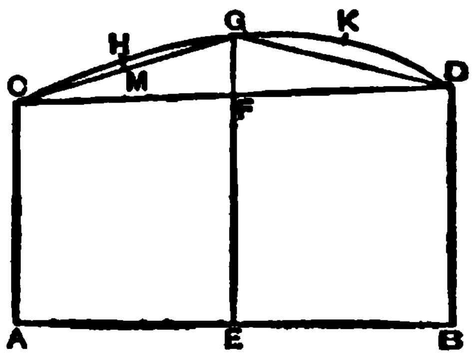
,, ,, $$P_3N_4 = m\left(\frac{a_3 + a_4}{2}\right)$$

$\therefore$ sum of trapeziums, *i.e.* area of figure $= m\left(\frac{a_1}{2} + a_2 + a_3 + \frac{a_4}{2}\right)$.

Simpson's First Rule. (Fig. 127.)

A parabolic segment is a curve such that the deflection of any arc is proportional to the square of its base.

FIG. 127.



Area of ACGDB = area of (ABDC + segment CGD).

Now area of segment CGD = area of triangles CGD + CHG + GKD + ...

$$\text{Area of CGD} = \frac{AB \times GF}{2}.$$

$$\text{Area of CHG} = \frac{AB}{2} \times \frac{HM}{2} \text{ but } HM = \tfrac{1}{4}\,GF$$

$$\left.\begin{array}{lll} ,, \quad ,, & = \dfrac{AB}{2} \times \dfrac{1}{8}\,GF = & \dfrac{AB \times GF}{16} \\ ,, \quad CHG = & GKD & = \dfrac{AB \times GF}{16} \end{array}\right\} = \frac{AB \times GF}{8}.$$

$$\text{Area of triangle CGD} \ldots = \frac{AB \times GF}{2}\left(1 + \frac{1}{4} + \frac{1}{16} + \ldots\right).$$

$$\text{Now the sum of } \left(1 + \frac{1}{4} + \frac{1}{16} + \ldots\right) = \frac{4}{3}.$$

$$\therefore \text{ area of segment CGD} = \frac{AC}{3}\left(\frac{AB \times GF}{2}\right) = \frac{2}{3}AB\left(EG - \frac{AC + BD}{2}\right)$$

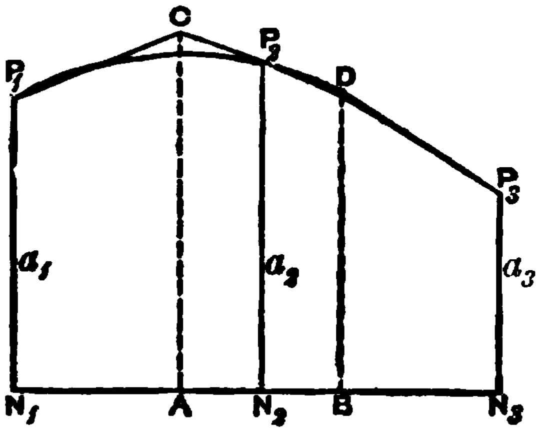
$$\text{Area of ACDB} = \frac{AC + BD}{2} \times AB.$$

$$\therefore \text{ total area} = AB\left(\frac{AC + BD}{2} + \frac{2}{3}EG - \frac{AC + BD}{3}\right)$$

$$= \frac{AB}{6}\left(AC + 4EG + BD\right) = \frac{AE}{3}(AC + 4EG + BD).$$

Let $P_1P_2N_2N_1$ be the area and $a_1a_2a_3$ the ordinates. Divide N_1N_3 into three equal parts by the perpendiculars AC, BD. At P_2 draw a tangent CD to the curve meeting AC and BD at C and D. Join P_1C, DP_3.

Fig. 128.



Area of sum of trapeziums, i.e. area of figure

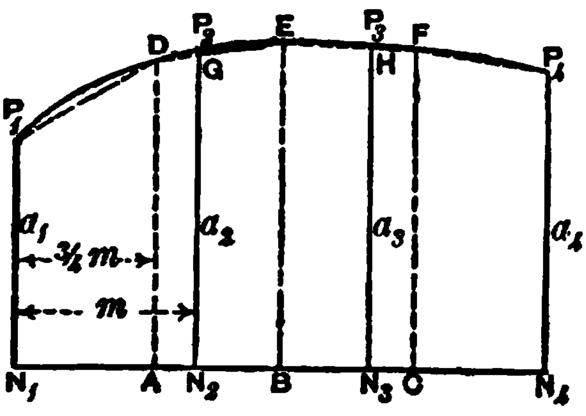
$$=\frac{AB}{3}\left(\frac{a_1}{2}+AC+BD+\frac{a_3}{2}\right)$$

But $AC+BD=2a_2$

$$\therefore \text{ area of figure}=\frac{AB}{6}\left(a_1+4a_2+a_3\right)$$

Simpson's Second Rule. (Fig. 129.)

Fig. 129.



Let $P_1P_4N_4N_1$ be the area $a_1a_2a_3a_4=$ the ordinates $m=$ the common interval. Divide N_1N_4 into four equal parts by the ordinates AB, BC, CF, and draw AD, BE, CF perpendicular to N_1N_4, meeting the curve in D, E, F. Join P_1D, DE, EF, FP_4. Let the straight lines DE and EF cut P_2N_2 and P_3N_3 in G and H respectively. Now $N_1A=AB=BC=CN_4=3/4m$.

$$\text{Area of trapezium } P_1A=\frac{3m}{4}\left(\frac{P_1N_1+AD}{2}\right)=\frac{3m}{8}\left(a_1+AD\right)$$

$$\text{,, ,, } DB=\frac{3m}{4}\left(\frac{AD+BE}{2}\right)=\frac{3m}{8}\left(AD+BE\right)$$

$$\text{,, ,, } EC=\frac{3m}{4}\left(\frac{BE+CF}{2}\right)=\frac{3m}{8}\left(BE+CF\right)$$

$$\text{,, ,, } FN_4=\frac{3m}{4}\left(\frac{CF+N_4P_4}{2}\right)=\frac{3m}{8}\left(CF+a_4\right).$$

$$\therefore \text{ sum of all trapeziums}=\frac{3}{8}m(a_1+a_4+2AD+2BE+2CF).$$

In the figure $N_2G=AD+\frac{1}{3}(BE-AD)=\dfrac{2(AD+BE)}{3}$.

$\therefore$ $2\,AD+BE=3\,N_2G=3\,P_2N_2$ nearly since G is very near P_2, the ordinates not being very far apart. In the same manner $2CF+BE=3\,P_3N_3$ nearly.

$\therefore$ sum of all trapeziums $=\frac{3}{8}m\left(a_1+a_4+3a_2+3a_3\right)$, and since putting P_2N_2 and P_3N_3 instead of N_2G and N_3H will give a small increase to the area above that of the trapeziums and the curvilinear area is also a small increase over that of the same trapeziums, it is seen that approximately the curvilinear area

$$=3/8\,(a_1+3a_2+3a_3+a_4).$$

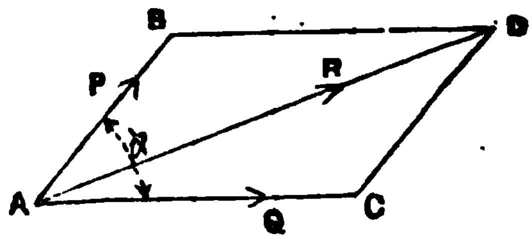
MECHANICAL PRINCIPLES.

RESULTANT AND RESOLUTION OF FORCES.

1. *To find the resultant of two forces acting through one point but not in the same direction.* (Fig. 130.)

Let AB, AC represent the two forces P and Q acting through the point A; complete the parallelogram ABCD: then its diagonal AD will represent in magnitude and direction the resultant of the two forces P and Q.

FIG. 130.



R = resultant. θ = angle P makes with Q.

a = angle R makes with Q. β = angle R makes with P.

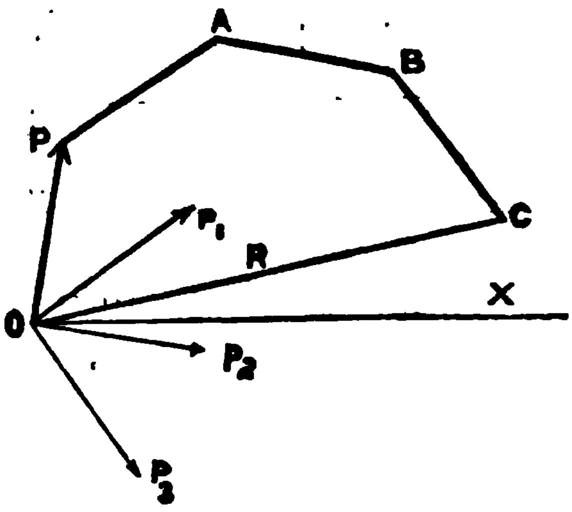
$$R = \sqrt{P^2 + Q^2 + 2.P.Q.\cos\theta};$$

$$\sin a = \sin\theta\frac{P}{R}; \quad \sin\beta = \sin\theta\frac{Q}{R}.$$

2. *To find the resultant of any number of forces acting in the same plane and through one point but not in the same direction.* (Fig. 131.)

Let P, P_1, P_2, P_3 be the forces acting through the point of application O; commence at O and construct a chain of lines OP, PA, AB, BC, representing the forces in magnitude and parallel to them; let C be the end of the chain: then a line R joining OC will represent in magnitude and direction the resultant of the forces P, P_1, P_2, and P_3.

FIG. 131.



Note.—This *geometrical* problem is true whether the forces act in the same or in different planes.

R = resultant.

θ = angle made by R with a fixed axis OX.

a, a_1, a_2, &c. = angles made by the forces P, P_1, P_2, &c., with OX.

ΣX = sum of the series of $P.\cos a + P_1.\cos a_1 + P_2.\cos a_2$, &c.

ΣY = sum of the series of $P.\sin a + P_1.\sin a_1 + P_2.\sin a_2$, &c.

$$R.\cos\theta = \Sigma X. \quad R = \sqrt{(\Sigma X)^2 + (\Sigma Y)^2}$$

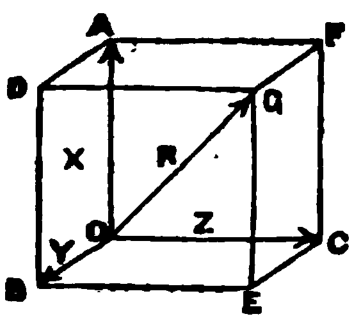
$$R.\sin\theta = \Sigma Y. \quad \tan\theta = \frac{\Sigma Y}{\Sigma X}$$

$$\cos\theta = \frac{\Sigma X}{R}$$

$$\sin\theta = \frac{\Sigma Y}{R}.$$

3. *To find the resultant of three forces acting through one point and making right angles with one another.* (Fig. 132.)

FIG. 132.



Let OA, OB, OC represent in magnitude and direction the forces X, Y, Z acting through one point O; complete the rectangular solid AEFB: then its diagonal OG will represent in magnitude and direction the resultant of the forces X, Y, Z.

R = resultant.

α, β, γ = the angles R makes with X, Y, Z, respectively.

$$Y = R \,.\, \cos \beta. \quad R = \sqrt{X^2 + Y^2 + Z^2}.$$
$$Z = R \,.\, \cos \gamma. \quad X = R \,.\, \cos \alpha.$$

4. *To find the resultant of any number of forces acting through one point in different directions and not in the same plane.*

Let P, P_1, P_2, &c., be the forces α, β, γ; $\alpha_1, \beta_1, \gamma_1$; $\alpha_2, \beta_2, \gamma_2$, the angles their directions make with three axes passing through the point of application and making right angles with one another.

N.B. Cosines of obtuse angles are negative.

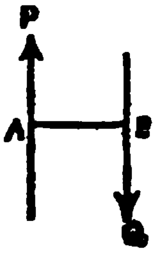
R = resultant.

$$\Sigma X = P \,.\, \cos \alpha + P_1 \,.\, \cos \alpha_1 + P_2 \,.\, \cos \alpha_2 + \&c.$$
$$\Sigma Y = P \,.\, \cos \beta + P_1 \,.\, \cos \beta_1 + P_2 \,.\, \cos \beta_2 + \&c.$$
$$\Sigma Z = P \,.\, \cos \gamma + P_1 \,.\, \cos \gamma_1 + P_2 \,.\, \cos \gamma_2 + \&c.$$
$$R = \sqrt{(\Sigma X)^2 + (\Sigma Y)^2 + (\Sigma Z)^2}$$
$$\cos \alpha = \frac{\Sigma X}{R}$$
$$\cos \beta = \frac{\Sigma Y}{R}$$
$$\cos \gamma = \frac{\Sigma Z}{R}.$$

PARALLEL FORCES.

A couple consists of two equal forces, as P and Q (see fig. 133), acting in parallel and opposite directions to one another, and is termed a right- or left-handed couple, according to whether the forces tend to turn the rigid body in a right- or left-handed direction.

FIG. 133.



The moment of a couple is the product of either of the forces into the perpendicular distance AB between the lines of direction of the forces. The distance AB is termed the arm or lever of the couple.

5. *To find the resultant moment of any number of couples acting upon a body in the same or parallel planes.*

RULE.—Add together the moments of the right- and left-

handed couples separately; the difference between the two sums will be the resultant moment, which will be right- or left-handed, according to which sum is the greater.

6. *To find the resultant of two parallel forces.* (Figs. 134 and 135.)

The magnitude of the resultant of two parallel forces is their sum or difference, according to whether they act in the same or contrary directions.

Let fig. 134 represent a case in which the two forces act in the same direction, and fig. 135 a case in which the components act in opposite directions.

Let AB and CD represent the two forces; join AD and CB, cutting each other in E; in DA (produced in fig. 135) take DF = BA; through F draw a line parallel to the components; this will be the line of the resultant, and if two lines DG and AH be drawn parallel to BC, cutting the line of action of the resultant in G and H, GH will represent the magnitude of the resultant.

FIG. 134.

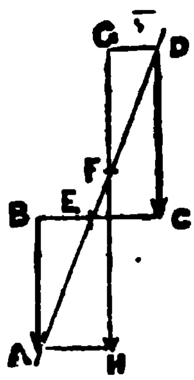
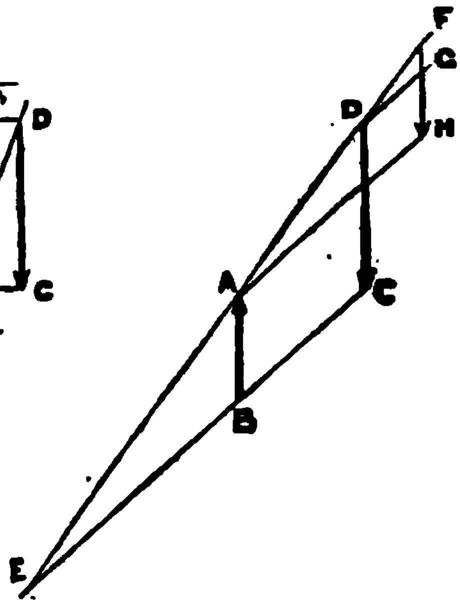


FIG. 135.



$$AF = \frac{DC \, . \, AD}{GH}. \qquad DF = \frac{AB \, . \, AD}{GH}.$$

7. *To find the resultant of any number of parallel forces.*

RULE.—Take the sum of all those forces which act in *one* direction, and distinguish them as positive; then take the sum of all the other forces which act in the *contrary* direction, and distinguish them as negative. The direction of the resultant (positive or negative) will be in that of the greater of these two sums, and its magnitude will be the difference between them.

8. *To find the position of the resultant of any number of parallel forces when they act in two contrary directions.*

RULE.—1st. Multiply each force by its perpendicular distance from an assumed axis in a plane perpendicular to the lines of action of the forces; distinguish those moments into right- and left-handed, and take their resultant, which divide by the resultant force: the quotient will be the perpendicular distance of that force from the assumed axis.

2nd. Find by a similar process the perpendicular distance of the resultant force from another axis perpendicular to the first and in the same plane.

CENTRE OF GRAVITY.

1. *To find the moment of a body's weight relatively to a given plane.*

RULE.—Multiply the weight of the body by the perpendicular distance of its centre of gravity from the given plane.

2. *To find the common centre of gravity of a set of detached bodies relatively to a given plane.*

RULE.—Find their several moments relatively to a fixed plane; take the algebraical sum or resultant of those moments and divide it by the total sum of all the weights: the quotient will be the perpendicular distance of the common centre of gravity from the given plane.

Note.—When the moments of some of the weights lie on one side of the plane, and some on the other, they must be distinguished into positive and negative moments, according to the side of the plane on which they lie, and the difference between the two sums of the positive and negative moments will be the resultant moment. The sign of the resultant will show on which side the common centre of gravity lies.

Let w, w^1, w^2, &c. = the several weights.

d, d^1, d^2, &c. = the several perpendicular distances of the centres of gravity of w, w^1, w^2, &c., from the plane of moments.

D = the perpendicular distance of their common centre of gravity from the plane of moments.

$$D = \frac{wd + w^1d^1 + w^2d^2 + \&c.}{w + w^1 + w^2 + \&c.}$$

3. *To find the centre of gravity of a body consisting of parts of unequal heaviness.*

RULE.—Find separately the centre of gravity of these several parts, and then treat them as detached weights by the foregoing rule.

4. *To find the distance through which the common centre of gravity of a set of detached weights moves when one of those weights is shifted into a new position.*

RULE.—multiply the weight moved by the distance through which its centre of gravity is shifted; divide the product by the sum total of the weights: the quotient will be the distance through which the common centre of gravity has moved in a line parallel to that in which the weight was shifted.

Let w = weight shifted.

d = distance through which w was moved.

W = sum total of weights.

D = distance through which the common centre of gravity has moved in a line parallel to that in which the shifted weight was moved.

$$D = \frac{wd}{W}; \quad d = \frac{DW}{w}.$$

LAWS OF MOTION.

Impulse is the product of a force into the time during which it acts.

Momentum is the product of the mass of a body into its velocity.

The *mass* of a body is equal to its weight divided by the velocity which that weight produces during one second of unresisted fall.

GRAVITY.

g = force of gravity in feet per second.
l = latitude of the place.
h = height above the level of the sea.
r = radius of earth in feet = 20,900,000 feet.

$$g = 32{\cdot}1695\{1 - {\cdot}00284(\cos 2l)\}\left(1 - \frac{2h}{r}\right).$$

If $2l$ be obtuse, then

$$g = 32{\cdot}1695[1 + {\cdot}00284(\cos 180 - 2l)]\left(1 - \frac{2h}{r}\right).$$

UNIFORM ACCELERATING FORCE.

W = weight of body.
M = mass of body.
F = accelerating force, or unbalanced effort.
I = impulse exerted by F.
E = energy exerted by F.
t = time during which F acts in seconds.
d = distance through which F acts in feet.
v = original velocity.
v' = increased velocity.
g = force of gravity = 32·2 nearly.
m = mean velocity.

$$\mathrm{I} = \mathrm{F}t = \mathrm{M}(v' - v) = \frac{\mathrm{W}(v' - v)}{g} = \text{increase of momentum.}$$

$$\mathrm{E} = \mathrm{F}d = \mathrm{F}tm = \frac{\mathrm{M}(v'^2 - v^2)}{2} = \frac{\mathrm{W}(v'^2 - v^2)}{2g}.$$

UNIFORM RETARDING FORCE.

The foregoing formula will apply in this case, with the exception that $v - v'$ must be used instead of $v' - v$, and $v^2 - v'^2$ instead $v'^2 - v^2$, F denoting the *retarding force* and E denoting the work performed.

VELOCITY OF FALLING BODIES.

h = height or depth of fall in feet.
t = time of fall in seconds.
v = velocity acquired at end of time t.
g = accelerating force of gravity = 32·2 nearly.

$$v = gt = \frac{2h}{t} = \sqrt{2gh}; \quad h = \frac{vt}{2} = \frac{gt^2}{2} = \frac{v^2}{2g}; \quad t = \sqrt{\frac{2h}{g}} = \frac{v}{g} = \frac{2h}{v}.$$

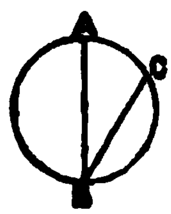
The velocity acquired by a body falling down an incline is equal to that which it would acquire in falling down its perpendicular altitude (see fig. 136).

FIG. 136.

t = time falling from B to A in seconds.
l = length of incline BA in feet.
h = altitude of incline BC in feet.
g = accelerating force of gravity = 32·2 nearly.

$$t = \sqrt{\frac{2l^2}{gh}}.$$

FIG. 137.



If a chord BC be drawn from either extremity of a vertical diameter AB of a circle, the time of descent of a body falling down the chord BC will equal the time of descent down the diameter AB (see fig. 137).

ROTATION ACCELERATED AND RETARDED.

Accelerated.

W = weight of body in lbs.
M = moment of accelerating force in foot lbs.
E = energy exerted.
v = original angular velocity.
v' = increased angular velocity.
θ = the circular motion during the action of the force in circular measure.
n = original speed of circular motion in turns per second.
n' = increased speed of circular motion in turns per second.
r = length of arm at the end of which W revolves in feet.
t = time during which M acts in seconds.
g = force of gravity = 32·2 nearly.

$$\text{M}t = \frac{\text{W}r^2(v' - v)}{g} = \frac{2\pi \text{W}r^2(n' - n)}{g}.$$

$$\text{E} = \text{M}\theta = \text{M}t\frac{v' + v}{2} = \frac{\text{W}r^2(v'^2 - v^2)}{2g} = \frac{4\pi^2 \text{W}r^2(n'^2 - n^2)}{2g}.$$

Retarded.

Use the same notation as for acceleration, but substituting moment of *retarding force* for moment of *accelerating force, diminution* for *increase* of velocity and its square, and *work performed* for *energy exerted.*

MOMENT OF INERTIA OF WEIGHT AND RADIUS OF GYRATION.

(See also pp. 59–63.)

m, m', m'', &c. = weight of indefinitely small particles composing the body.
d, d', d'', &c. = respective distances of m, m', m'', &c., from a fixed axis.
W = weight of whole body $= m + m' + m'' +$ &c.
I = moment of inertia of W about a fixed axis.
R = radius of gyration.

$$R = \sqrt{\frac{I}{W}}. \quad I = md^2 + m'd'^2 + m''d''^2 + \&c.$$

IMPULSE ON A FREE SOLID BODY.

A *single impulse* acting on a body through its centre of gravity impresses a motion of translation in the direction of the impulse.

V = velocity of translation in ft. per second.
F = force applied.
t = time during which F acts in ft. per second.
g = accelerating force of gravity = 32·2 nearly.
w = weight of body.

$$V = \frac{Fgt}{w}. \quad F = \frac{Vw}{gt}.$$

The *impulse of a couple* impresses on a body a motion of rotation about its centre of gravity.

A = angular velocity in circular measure.
L = linear velocity produced by one of two impulses.
F = force applied.
W = weight of body.
I = moment of inertia of W.
R^2 = square of radius of gyration.
l = length of arm of couple.
m = moment of couple.
t = time during which F acts.
g = accelerating force of gravity = 32·2 nearly.

$$A = \frac{mtg}{I} = \frac{Fltg}{WR^2} = \frac{Ll}{R^2}.$$

Table Giving the Lengths of Pendulums in Inches that Vibrate Seconds in Various Latitudes.			
Sierra Leone	39·01997	New York	39·10120
Trinidad	39·01888	Bordeaux	39·11296
Madras	39·02630	Paris	39·12877
Jamaica	39·03503	London	39·13907
Rio Janeiro	39·04350	Edinburgh	39·15540

Simple Pendulum.

L = length of pendulum in feet.
T = time of one vibration in seconds.
N = number of vibrations per minute.
g = force of gravity = 32·2 nearly.
π = 3·1416 nearly.

$$N = \frac{60\sqrt{g}}{\pi\sqrt{L}} = \frac{108{\cdot}36}{\sqrt{L}}.$$

$$L = g\left(\frac{T}{\pi}\right)^2 = {\cdot}326T^2.$$

$$T = \pi\sqrt{\frac{L}{g}} = {\cdot}554\sqrt{L}.$$

The length of a pendulum vibrating seconds at 45° latitude equals 39·11346 ins. nearly. In latitudes less than 90° the length equals 39·11346 [1 − ·00284 (cos ·2 lat.)]. In latitudes exceeding 90° the length equals 39·11346 [1 + ·00284 (cos ·180° − 2 lat.)].

Deviating and Centrifugal Force.

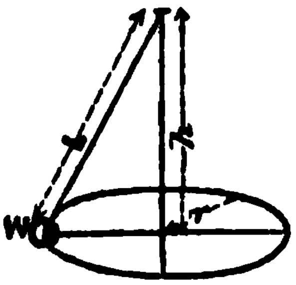
F = deviating force of body revolving in a circle at a uniform speed.
W = weight of body.
N = number of revolutions per minute.
n = number of revolutions per second.
v = linear velocity in feet per second.
a = angular velocity in circular measure per second.
r = radius of circle in feet.
g = accelerating force of gravity = 32·2 nearly.

$$F = \frac{Wv^2}{gr} = \frac{Wra^2}{g} = \frac{4Wn^2\pi^2r}{g} = \frac{Wn^2r}{{\cdot}8154} = \frac{WN^2r}{2935}.$$

Centrifugal force is exactly equal and opposite to the deviating force.

Revolving Pendulum (Fig. 138).

Fig. 138.



F = deviating force.
W = weight of bob.
N = number of revolutions per minute.
n = number of revolutions per second.
h = height of pendulum in feet.
r = radius of circle in feet.
g = accelerating force of gravity = 32·2 nearly.

$$h = \frac{Wr}{F} = \frac{g}{4\pi^2 n^2} = \frac{\cdot 8154}{n^2} = \frac{2935}{N^2}$$

$$n = \sqrt{\frac{\cdot 8154}{h}} \qquad N = \sqrt{\frac{2935}{h}}$$

DISPLACEMENT, ETC.

Computation of a Ship's Displacement.

This consists in computing the volume of the body of the vessel below the water-plane, up to which it is required to know her displacement, by one of the rules used for finding the volume of solids bounded on one side by a curved surface (see pp. 47, 48).

Two processes are generally made use of in computing a vessel's displacement, as the calculations in each process are required to determine the position of the centre of gravity of displacement, or centre of buoyancy, and also because the two results are a check on the correctness of the calculations.

One process consists in dividing the length of the ship on the load water-line by a number of equidistant vertical sections, computing their several areas by one of Simpson's rules, and then treating them as if they were the ordinates of a new curve, the base of which is the load water-line.

The other process consists in dividing the depth of the vessel below the load water-line by a number of equidistant longitudinal planes parallel to the load water-line; the areas of their several planes are then computed by one of Simpson's rules, and those areas are treated as if they were the ordinates of a new curve, the base of which is the vertical distance between the load water-line and first lowest longitudinal plane.

As the vessel generally consists of two symmetrical halves, the volume of only half the vessel, below the load water-line, is calculated, the ordinates all being measured from a longitudinal vertical plane at the middle of the ship.

If the vessel trims, the portion below the lowest water-line is treated, together with the stern, rudder, bilge keels, &c., as an appendage, its volume being calculated by means of equidistant vertical sections. Similarly if the keel is not straight, as in yachts and torpedo boats.

For example of displacement papers see pp. 82 and 83.

Determination of a Ship's Centre of Buoyancy for the Upright Position.

The centre of buoyancy is also termed the centre of gravity of displacement, as it occupies the same point as the centre of gravity of the volume of water displaced by the vessel, and its position is determined by the rules used for finding the centre of gravity of solids, bounded on one side by a curved surface (see rules, pp. 57 and 58), with the exception that its position need only be determined for its vertical distance from a horizontal plane, and its horizontal distance from a vertical plane; for the ship consisting of two symmetrical halves, it must necessarily lay in the longitudinal vertical plane in the middle of the ship.

Calculation of the centre of buoyancy is generally performed on the displacement paper (see pp. 82 and 83).

Vertical Height of Transverse Metacentre above Centre of Buoyancy for Upright Position.

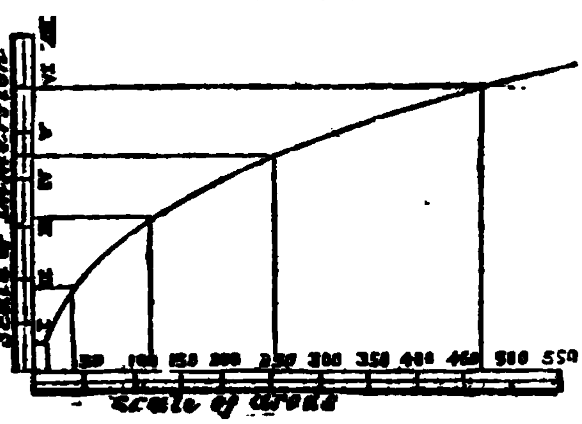
The transverse metacentre of vessel for all angles of heel always lies in a longitudinal vertical plane bisecting the ship, and vertically over its corresponding centre of buoyancy; its vertical height above the centre of buoyancy for its upright position is found by dividing the moment of inertia of the load water-plane relatively to the middle line of the vessel by the volume of displacement (see pp. 94 and 106). This calculation is also generally performed upon the displacement paper (see p. 82).

Curve of Areas of Midship Section.

This curve (see fig. 139) is used to determine the area of the immersed part of the midship section of a vessel at any given draught of water.

Method of Construction.—Compute the areas of the midship section from the keel up to the several longitudinal water-planes which are used for calculating the displacement; set these areas off along a base line as ordinates, in their consecutive order, the abscissæ of which represent to scale the respective distances between the longitudinal water-planes: a curve bent through the extremities of these ordinates will form the required curve.

Fig. 139.

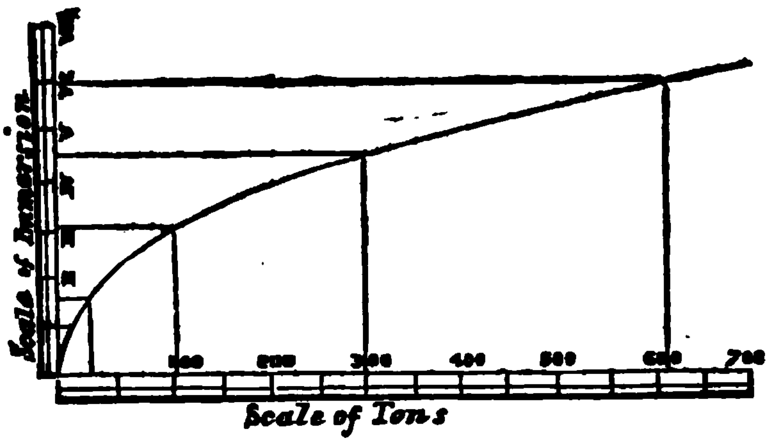


CURVE OF DISPLACEMENT.

This curve is used to determine the displacement a vessel has at any draught of water parallel to the load water-line (see fig. 140).

Method of Construction.—This curve is constructed in a similar manner to the foregoing curve, with the exception that the ordi-

FIG. 140.



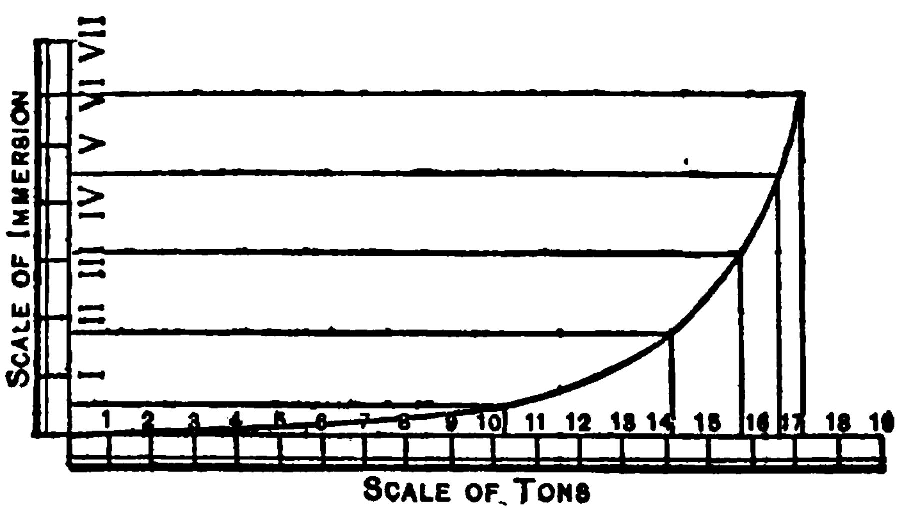
nates represent the several volumes of displacement (in tons of 35 cubic feet for salt water, and 36 cubic feet for fresh water) up to their respective longitudinal water-planes.

CURVE OF TONS PER INCH OF IMMERSION.

This curve (see fig. 141) is used to determine the number of tons required to immerse a vessel one inch at any draught of water parallel to the load water-plane.

To find the displacement per inch in cubic feet at any water-plane, divide the area of that plane by 12; and if the displace-

FIG. 141.



ment per inch is required in tons, divide by 35 or 36, as the case may be.

A = area of longitudinal water-plane in square feet.

T = tons per inch of immersion at that water-plane.

$$T = \frac{A}{12 \times 35} \text{ for salt water; } T = \frac{A}{12 \times 36} \text{ for fresh water.}$$

Method of Construction.—This curve is also constructed in a similar manner to the two foregoing curves, with the exception that the ordinates represent to scale the tons per inch of immersion at the respective water-planes.

Coefficients of Fineness.

The coefficient of fineness of displacement of a vessel is the ratio that the volume of the displacement bears to the parallelopipedon circumscribing the immersed body.

V = volume of displacement in cubic feet.
L = length of vessel at load water-line in feet.
B = extreme immersed breadth in feet.
D = draught of water in feet.
K = coefficient of fineness.

$$K = \frac{V}{L \times B \times D}.$$

The coefficient of fineness of a midship section, or of a water-plane, is the ratio which their respective areas bear to that of their circumscribing rectangle.

To determine the mean coefficient of all the water-planes of a ship.

Rule.—Multiply the immersed area of the midship section by the length of the load water-line, and divide the volume of displacement by the product.

Table of Coefficients of Fineness.

Class of Ship	Length	Breadth	Mean Draught	Coeff. of Dispt.	Coeff. of Mid. Sect.	Coeff. of Water-lines
	Feet	Feet	Feet			
Fast steamer, H.M. Royal Yacht	300·0	40·27	14·0	·414	·711	·711
Swift steam cruisers — H.M.S. 'Inconstant'	337 3	50·28	22·75	·483	·787	·614
Swift steam cruisers — H.M.S. 'Volage'	270·0	42·0	19·0	·497	·792	·628
Royal mail steamers — National Line	385·0	42·0	22·0	·659	·880	·800
Royal mail steamers — Peninsular and Oriental	368·27	42·5	18·71	·516	·812	·635
Royal mail steamers — Anchor Line	350·0	35·0	21·0	·687	·850	·840
Troopships — H.M.S. 'Serapis'	360·0	49·12	23·5	·470	·674	·700
Troopships — H.M.S. 'Himalaya'	340·5	46·13	15·75	·400	·680	·582
Modern rigged ironcl., H.M.S. 'Hercules'	325 0	59·0	24·75	·640	·810	·710
Modern mastless ironclads — H.M.S. 'Devastation'	285·0	62·25	26·5	·684	·809	·767
Modern mastless ironclads — H.M.S. 'Cyclops'	225·0	45·0	15·0	·715	·932	·755
Composite gun boats — H.M.S. 'Ariel'	125·0	23·0	8·0	·536	·870	·616
Composite gun boats — H.M.S. 'Sappho'	160·0	31·33	12·0	·466	·745	·608
Small merchant vessels — from	220·0	27·0	8·0	·702	·912	·742
Small merchant vessels — to	90·0	17·5	4·0	·687	·914	·704

Table showing Method of Computing a Ship's Displacement, the Position of her Centre of Buoyancy, etc., when whole Intervals are used.

No. of Sections	Mults.	Water Line 1 (Simpson's Mult. 1)		Water Line 2 (Simpson's Mult. 4)		Water Line 3 (Simpson's Mult. 2)		Water Line 4 (Simpson's Mult. 4)		Water Line 5 (Simpson's Mult. 1)		Vertical Sections: Funcs. of Hf. Areas	Mults.	Mults. of Funcs.	Levers	Prods. for Moms.	Metacentre: Cubes of Ordinates	Prods. by Simps. Mults.
1	1	**·0** ·0	·0	**·2** ·8	·2	**·2** ·4	·2	**·2** ·8	·2	**·2** ·2	·2	2·2	1	2·2	0	·0	·00	·00
2	4	**·2** ·2	·8	**2·3** 9·2	9·2	**4·2** 8·4	16·8	**5·6** 22·4	22·4	**6·8** 6·8	27·2	47·0	4	188·0	1	188·0	314·43	1257·72
3	2	**·2** ·2	·4	**6·4** 25·6	12·8	**9·2** 18·4	18·4	**10·8** 43·2	21·6	**11·9** 11·9	23·8	99·3	2	198·6	2	397·2	1685·15	3370·30
4	4	**·2** ·2	·8	**9·9** 39·6	39·6	**13·1** 26·2	52·4	**14·3** 57·2	57·2	**15·0** 15·0	60·0	138·2	4	552·8	3	1658·4	3375·00	13500·00
5	2	**·2** ·2	·4	**12·3** 49·2	24·6	**15·3** 30·6	30·6	**16·0** 64·0	32·0	**16·2** 16·2	32·4	160·2	2	320·4	4	1281·6	4251·52	8503·04
6	4	**·2** ·2	·8	**13·5** 54·0	54·0	**16·0** 32·0	64·0	**16·5** 66·0	66·0	**16·5** 16·5	66·0	168·7	4	674·8	5	3374·0	4492·12	17968·48
7	2	**·2** ·2	·4	**13·8** 55·2	27·6	**16·0** 32·0	32·0	**16·5** 66·0	33·0	**16·5** 16·5	33·0	169·9	2	339·8	6	2038·8	4492·12	8984·24
8	4	**·2** ·2	·8	**13·7** 54·8	54·8	**16·0** 32·0	64·0	**16·5** 66·0	66·0	**16·5** 16·5	66·0	169·5	4	678·0	7	4746·0	4492·12	17968·48
9	2	**·2** ·2	·4	**12·8** 51·2	25·6	**15·7** 31·4	31·4	**16·4** 65·6	32·8	**16·4** 16·4	32·8	164·8	2	329·6	8	2636·8	4410·94	8821·88
10	4	**·2** ·2	·8	**10·6** 42·4	42·4	**14·8** 29·6	59·2	**16·1** 64·4	64·4	**16·3** 16·3	65·2	152·9	4	611·6	9	5504·4	4330·74	17322·96
11	2	**·2** ·2	·4	**6·4** 25·6	12·8	**11·5** 23·0	23·0	**14·5** 58·0	29·0	**15·6** 15·6	31·2	122·4	2	244·8	10	2448·0	3796·41	7592·82
12	4	**·2** ·2	·8	**1·9** 7·6	7·6	**5·4** 10·8	21·6	**9·3** 37·2	37·2	**12·6** 12·6	50·4	68·4	4	273·6	11	3009·6	2000·37	8001·48
13	1	**·2** ·2	·2	**·2** ·8	·2	**·2** ·4	·2	**·2** ·8	·2	**·2** ·2		2·4	1	2·4	12	28·8	·00	·00
			7·0		311·4		413·8		462·0		488·4			4416·6		27311·6		113291·4

7·0 × 1, 311·4 × 4, 413·8 × 2, 462·0 × 4, 488·4 × 1

4416·6 = 7·0 + 1245·6 + 827·6 + 1848·0 + 488·4

× 4, 3, 2, 1, 0

7268·0 = 28·0 + 3736·8 + 1655·2 + 1848·0 + ·0

4416·6)7268·0
1·64
Vert. Int. 3·812
6·2517
C. of Buoy. below W.L. 5.

4416·6)27311·6
6·183
Long. Int. 16·6
102·638
C. of Buoy. abaft No. 1 section.

4416·6
⅓ Vert Int. 1·2708
5612·61528
Long. Int. 16·6
3)93169·413648
31056·47
2
Cub. ft. in a ton 35)62112·94*
1774·65
Dispt. to Water-Line 5

113291·4
Long. Int. 16·6
3)1880637·24
*62112·9)626879·08
10·09
2
3)20·18
6·727
Metacentre above C. of Buoy.

⅓ Vert. Int. 169·9
Function 1·2708
114372
114372
76248
12708
215·90892
2
431·8
Area of No. 7 Vert. Section.

488·4
Long. Int. 16·6
29304
29304
4884
3)8107·44
2702·48
2
7)5404·96
5)772·137
12)154·427
12·869
Dispt. per in. at W. Line No. 5.

311·4×1= 311·4
413·8×4=1655·2
462·0×1= 462·0
2428·6
⅓ Vert. Int. 1·27
3084·322
Long. Int. 16·6
3)51199·745
17066·58
2
7)34133·16
5)4876·16
−975·43
Dispt. to W. L. No. 4 1195·76
220·33
Dispt. to W. Line No. 2.

7·0×1= 7·0
311·4×4=1245·6
413·8×1= 413·8
1666·4
⅓ Vert. Int. 1·27
2116·328
Long. Int. 16·6
3)35131·0448
11710·35
2
7)23420·70
5)3345·81
669·16
Dispt. to W. Line No. 3.

7·0×1= 7·0
311·4×3= 934·2
413·8×3=1241·4
462·0×1= 462·0
2644·6
⅜ Vert. Int. 1·43
3781·778
Long. Int. 16·6
3)62777·148
20925·838
2
7)41851·676
5)5978·81
1195·76
Dispt. to W. Line No. 4.

Long. Interval between Ordinates=16·6 ft. Vert. Interval between Water-Lines=3·8125 ft.

N.B. The dark figures are the ordinates; the light figures under them and also to their right are the products of the ordinates by their respective Simpson's multipliers, which are placed at the head and also to the left of the table; and if each row and column of these products be added together, and the results integrated by the same multipliers as were used before, and the sums of these products added together, the two sums will agree if the calculations are correct. The divisor used to find the centre of buoyancy bears the same ratio to its dividend as the sum of the products of the functions of half-areas bears to the displacement. * Volume of displacement in cub. ft.

TABLE SHOWING METHOD OF COMPUTING A SHIP'S DISPLACEMENT, ETC., WHEN SUBDIVIDED INTERVALS ARE USED.

No. of Sections	Mults.	Water Line 1		Water Line 1½		Water Line 2		Water Line 2½		Water Line 3		Water Line 4		Water Line 5		Displacement by Vertical Sections: Functs. of Areas	Sim. Mul.	Mults. of Functs.	Centre of Buoyancy by Vertical Sections: Leverages	Products for Moments
		Simpson's Multipliers																		
		½		2		1		2		1½		4		1						
1	1	·00 ·00	·00	·00 ·00	·00	·00 ·00	·00	·00 ·00	·00	·00 ·00	·00	·00 ·00	·00	·10 ·10	·10	·10	1	·10	0	·00
2	4	·30 ·15	1·20	2·90 5·80	11·60	3·70 3·70	14·80	4·10 8·20	16·40	4·40 6·60	17·60	4·90 19·60	19·60	5·20 5·20	20·80	49·25	4	197·00	1	197·00
3	2	2·70 1·35	5·40	6·70 13·40	13·40	7·60 7·60	15·20	8·10 16·20	16·20	8·40 12·60	16·80	8·90 35·60	17·80	9·40 9·40	18·80	96·15	2	192·30	2	384·60
4	4	4·90 2·45	19·60	9·40 18·80	37·60	10·30 10·30	41·20	10·90 21·80	43·60	11·20 16·80	44·80	11·50 46·00	46·00	11·90 11·90	47·60	128·05	4	512·20	3	1536·60
5	2	6·50 3·25	13·00	11·10 22·20	22·20	12·00 12·00	24·00	12·50 25·00	25·00	12·80 19·20	25·60	12·90 51·60	25·80	13·00 13·00	26·00	146·25	2	292·50	4	1176·00
6	4	7·30 3·65	29·20	11·90 23·80	47·60	12·80 12·80	51·20	13·20 26·40	52·80	13·40 20·10	53·60	13·50 54·00	54·00	13·50 13·50	54·00	154·25	4	617·00	5	3085·00
7	2	7·80 3·90	15·60	12·00 24·00	24·00	12·90 12·90	25·80	13·30 26·60	26·60	13·50 20·25	27·00	13·50 54·00	27·00	13·50 13·50	27·00	155·15	2	310·30	6	1861·80
8	4	7·80 3·90	31·20	12·00 24·00	48·00	12·90 12·90	51·60	13·30 26·60	53·20	13·50 20·25	54·00	13·50 54·00	54·00	13·50 13·50	54·00	155·15	4	620·60	7	4344·20
9	2	7·40 3·70	14·80	12·00 24·00	24·00	12·90 12·90	25·80	13·30 26·60	26·60	13·50 20·25	27·00	13·50 54·00	27·00	13·50 13·50	27·00	154·95	2	309·90	8	2479·20
10	4	5·60 2·80	22·40	11·80 23·60	47·20	12·80 12·80	51·20	13·20 26·40	52·80	13·40 20·10	53·60	13·50 54·00	54·00	13·50 13·50	54·00	153·20	4	612·80	9	5515·20
11	2	2·30 1·15	4·60	10·50 21·00	21·00	12·00 12·00	24·00	12·80 25·60	25·60	13·20 19·80	26·40	13·40 53·60	26·80	13·40 13·40	26·80	146·55	2	293·10	10	2931·00
12	4	·30 ·15	1·20	7·50 15·00	30·00	10·00 10·00	40·00	11·30 22·60	45·20	12·20 18·30	48·80	12·90 51·60	51·60	13·10 13·10	52·40	130·75	4	523·00	11	5753·00
13	2	·30 ·15	·60	3·00 6·00	6·00	5·40 5·40	10·80	7·30 14·60	14·60	8·80 13·20	17·60	10·80 43·20	21·60	11·80 11·80	23·60	94·35	2	188·70	12	2264·40
14	4	·30 ·15	1·20	·40 ·80	1·60	1·20 1·20	4·80	2·00 4·00	8·00	3·10 4·65	12·40	5·60 22·40	22·40	8·00 8·00	32·00	41·20	4	164·80	13	4142·40
15	1	·00 ·00	·00	·10 ·20	·10	·10 ·10	·10	·10 ·20	·10	·10 ·15	·10	·10 ·40	·10	·10 ·10	·10	1·15	1	1·15	14	16·10
																		4835·45 For Displacement.		3[illegible]0·50 For horizontal position of Centre of Buoyancy.

	Water Line 1		Water Line 1½		Water Line 2		Water Line 2½		Water Line 3		Water Line 4		Water Line 5		
Functions of Areas	160·00		334·30		380·50		406·70		425·30		447·70		464·20		
	½		2		1		2		1½		4		1		
Mults. of Functions	80·00	+	668·60	+	380·50	+	813·40	+	637·95	+	1790·80	+	464·20	=	4835·45.
	4		3½		3		2½		2		1		0		
Prods. for Moments	320·0	+	2340·10	+	1141·50	+	2033·50	+	1275·90	+	1790·80	+	·00	=	11781·80 for vertical position of Centre of Buoyancy.

(Concluded on next page.)

4535·45)11791·20 (2·437
9070·90
⅓ Vertical Interval
3110800
1084160
4·874 {Centre of Buoyancy below Water-line 5 in feet
1767200
1450835
3183650

Functions of Water-line 5 464·3
⅓ Horizontal Interval 5·238 ft.
37136
13926
9284
23210
2431·479 sq. ft.
For both sides 2
Cub. ft. of water in a ton {(7)4862·958 sq. ft. (5) 694·708
For inches 12)138·941 tons per ft. immersion
11·58
Displacement in tons per inch at Water-line 5

Functions of section 7 155·15
⅓ Vertical Interval ·667 ft.
108605
93090
93090
Area of one side 103·485 sq. ft.
2
206·970 sq. ft.
Area of section 7.

4535·45
⅓ Vertical Interval ·667 ft.
3384815
2901270
2901270
3326·245
⅓ Horizontal Interval 5·238 ft.
26601960
9975735
6650490
16196385
Cubic feet 16693·843
For both sides 2
Cub. ft. of water in a ton {(7)33787·686 cubic feet (5) 4826·812
965·363
Displacement in tons to Load or 5th Water-line.

4535·45)53690·50(
8·965
Horizontal Interval 15·714 ft
77860
6965
48755
34825
6965
109·449010
Centre of Buoyancy abaft No. 1 section in ft.

160·0× 5= 800·0
334·3× 8= 2674·4
380·5×−1=−380·5
3093·9
$\frac{1}{32}$ Vertical Interval ·083 ft.
92817
247512
256·793
⅓ Horizontal Interval 5·238 ft.
2054344
770379
513586
1283965
1345·081 cub. ft.
For both sides 2
Cub. ft. of water in a ton {(7)2690·162 cub. ft. (5) 384·309
76·862
Displacement in tons to Water-line 1½.

160·0×1= 160·0
334·3×4=1337·2
380·5×1= 380·5
1877·2
⅓ Vertical Interval ·333 ft.
56316
56316
56316
625·107
⅓ Horizontal Interval 5·238 ft.
5000856
1875321
1250214
3125535
3274·310 cub. ft.
For both sides 2
Cub. ft. of water in a ton {(7)6548·620 c. ft. (5) 935·517
187·103
Displacement in tons to Water-line 2.

160·0×1= 160·0
334·3×3=1002·9
380·5×3=1141·5
406·7×1= 406·7
2711·1
$\frac{3}{12}$ Vertical Interval ·375 ft.
135555
189777
81333
1016·663
⅓ Horizontal Interval 5·238 ft.
8133296
3049988
2033324
5083310
5325·275 cub. ft.
For both sides 2
Cub. ft. of water in a ton {(7)10650·550 c. ft. (5) 1521·507
304·301
Displacement in tons to Water-line 2½.

160·0×1= 160·0
334·3×4=1337·2
390·5×2= 781·0
406·7×4=1626·8
435·3×1= 435·3
4310·3
⅓ Vertical Interval ·333 ft.
129309
129309
129309
1436·739
⅓ Horizontal Interval 5·238 ft.
11493912
4310217
2873478
7183695
7518·365 c. ft.
For both sides 2
Cub. ft. of water in a ton {(7)15036·730 c. ft. (5) 2148·075
429·615
Displacement in tons to Water-line 3.

464·3× 5= 2321·0
447·7× 8= 3581·6
435·3×−1=−435·3
5477·3
$\frac{1}{12}$ Vertical Interval ·167 ft.
383411
328638
54773
914·709
⅓ Horizontal Int. 5·238
ib. ft.
ib. ft.
Displacement in tons to Water-line 4.

Length in feet=220. Breadth in feet=37. Draught of water in feet=8. Horizontal distance between sections=15·714 feet. Vertical Interval=2 feet.

EXPLANATION OF DISPLACEMENT SHEET. (See pp. 83 and 84.)

The length of the ship at water-line 5 is divided into 14 equal intervals, and the depth or draught of water * into four equal intervals, the lower two being subdivided into half-intervals (for multipliers for subdivided intervals see p. 41). The ordinates, or half-breadths, at the intersections of the vertical cross sections with the horizontal sections are measured off in feet, and set down in *dark* figures in rows *opposite* their respective cross sections and *under* their respective horizontal sections, thus forming the numbers into columns.

Each of the ordinates in the several *columns* are then multiplied by the 'Simpson's multiplier' † at the head of their column, the products being set immediately below in *lighter* figures, and their sums taken in *rows* and placed to the right in the column headed 'functions of areas.'

Each of these 'functions of areas' is then multiplied by the 'Simpson's multiplier' † proper to its *row*, the products being placed to the right in the column headed 'multiples of functions,' and their sum taken.

Then, as a check upon the last result, it is usual to multiply each of the ordinates in the several *rows* by the 'Simpson's multiplier' to the left of their respective rows, the products being set in the adjoining *column* in *lighter* figures, and their sums taken in *columns* and placed below in the *row* of 'functions of areas.'

Each of these 'functions of areas' is then multiplied by the 'Simpson's multiplier' proper to its *column*, the products being placed below in the *row* of 'multiples of functions.' The sum total of these 'multiples of functions' should then exactly correspond to the sum total of the *column* of 'multiples of functions,' thus proving the correctness of the calculations thus far. The latter sum is then multiplied by $\frac{1}{3}$ of the vertical interval, and this again by $\frac{1}{3}$ of the horizontal interval between the ordinates. This last product is then multiplied by 2 for both sides of the ship, and the result divided by 35 (that being the number of cubic feet of salt water in a ton), which gives the total displacement of the ship in tons to water-line 5.

The *horizontal* distance of the 'centre of buoyancy' abaft the stem, or No. 1 section, is then found by multiplying each of the products in the *column* headed 'multiples of functions' by its multiplier for leverage (that being the number of intervals the cross section is distant from No. 1 section), the products being placed in the *column* headed 'product for moments.' The sum total of these divided by the sum of the *column* of 'multiples of functions,' and the quotient multiplied by the *horizontal* interval, will give the distance of the centre of buoyancy abaft No. 1 section in feet. The *vertical* distance of the 'centre of buoyancy' below water-line 5 is found by multiplying each of the products in the *row* of 'multiples of functions' by its multiplier for leverage (that being the number of intervals the horizontal section is from water-line 5), the products being placed below in the *row* of 'products for moments.' The sum total of these divided by the sum of the *row* of multiples of areas, and the quotient multiplied by the *vertical* interval, will give the vertical distance of the centre of buoyancy below water-line 5 in feet.

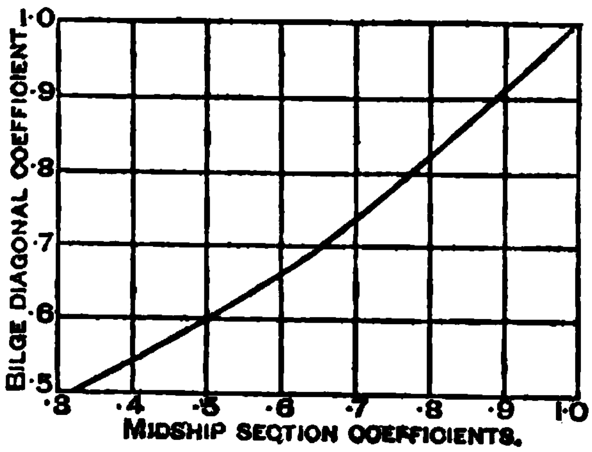
* Should the vessel have a bar keel, the depth should be taken from top of keel.

† To save time and labour, it is usual to substitute the halves of the multipliers for the multipliers themselves. Thus, instead of 1 4 2 4 . . . 1, substitute $\frac{1}{2}$ 2 1 2 . . . $\frac{1}{2}$. If this be done, the final result must be multiplied by 2; if it be done twice, as in a displacement sheet, it should be multiplied by 4.

METHOD OF OBTAINING DESIRED DISPLACEMENT IN DESIGNING SHIPS. (BY R. ZIMMERMANN, M.I.N.A.)

A curve is first constructed from ships already designed. A line is drawn in the body plan from the intersection of the L.W.L., with the middle line to the point where the rise of floor produced cuts the side line: this is called the bilge diagonal. The coefficient of this curve, expanded in the half-breadth, and also that of the midship sectional area, are calculated, and a curve set off, as shown in(fig.142) $= \dfrac{D \times 35}{L \times \text{area of midship section}}$.

FIG. 142.



The abscissæ are midship-section cylinder coefficients, and the ordinates are bilge diagonal coefficients.

The length, breadth, draught, displacement, and midship section being given, the midship-section cylinder coefficient is calculated, and set off as an abscissa to the curve; the ordinate gives the coefficient for the bilge diagonal. To enable the bilge diagonal to be drawn in the half-breadth plan, it is best to run in a parabola of the same area.

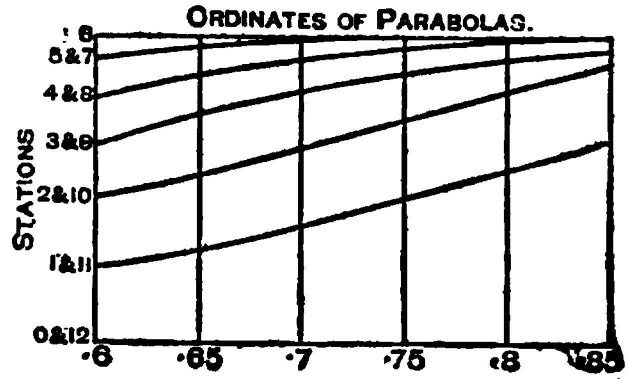
Let A = area of surface enclosed by the bilge diagonal.
B = length of bilge diagonal on midship section.
n = coefficient of the parabola; y = ordinates of parabola.
x = abscissæ on each side of centre line. L = length of load-line.

$$\text{Then } n = \frac{A}{LB - A} \text{ and } y = L\left(\frac{x}{B}\right)^n.$$

Fig. 143 shows ordinates of y set off for various coefficients; for six stations on each side at equal distances from the centre.

FIG. 143.

ORDINATES OF PARABOLAS.



These spots, set off in the half-breadth plan, give a parabola which will have to be altered a little. This altered line is the bilge diagonal necessary to obtain the desired displacement; the spots from it are transferred to the body plan, and the first two or three sections nearest the midship section can generally be drawn in at once, and one or two others may be sketched in, the spots on the gunwale serving as a guide. The load-line and outside buttock are then put in, and when these are fair with one another other buttocks and water-lines are drawn, and the ship is faired in the usual manner, always taking care not to alter the bilge diagonal in such a manner as to affect its fairness or area. When the ship is faired the displacement is calculated in the ordinary way.

THE USE OF THE MEAN WATER-LINE IN DESIGNING THE LINES OF SHIPS. (BY A. G. RAMAGE, ESQ., M.I.N.A.)

(*From Transactions of the Institution of Naval Architects*, 1897.)

DEFINITION.—The mean water-line of a vessel is the water-line whose area is equal to the volume of displacement in cubic feet, divided by the draught moulded.

It is evident that if it be known where the mean water-line should be for a particular type of vessel, we can run it in and rapidly reduce it to the required area. Also, this height will depend on the fineness or fulness of the midship section and load water-line.

In the table below are given the coefficients of load water-line area, area of midship section, and height of mean water-line corresponding (in a particular type of vessel) to the coefficients of fineness of displacement in the first column. The coefficient of height of mean water-line is equal to the actual height divided by the draught moulded.

The type of vessel chosen in the table is one with straight and round lines, and a club-foot section forward. The height of the mean water-line for other types will have to be slightly increased or decreased to suit. Having thus two water-lines of correct area, their shapes can be modified to suit the type of boat; the sections can then be sketched in, and any small error of displacement rectified by a slight alteration to the bilge.

TABLE OF COEFFICIENTS.

Coefficient of Fineness of Displacement.	Coefficient of Load Water-line Area	Coefficient of Area of Mid-ship Section	Coefficient of Height of Mean Water-line	Coefficient of Fineness of Displacement	Coefficient of Load Water-line Area	Coefficient of Area of Mid-ship Section	Coefficient of Height of Mean Water-line
·4	·70	·655	·453	·59	·750	·913	·410
·41	·705	·690	·450	·60	·755	·918	·408
·42	·705	·722	·448	·61	·760	·921	·404
·43	·706	·750	·446	·62	·765	·925	·400
·44	·707	·770	·445	·63	·772	·928	·396
·45	·709	·790	·444	·64	·780	·931	·392
·46	·710	·808	·442	·65	·785	·935	·388
·47	·711	·823	·440	·66	·790	·938	·385
·48	·713	·835	·439	·67	·800	·940	·380
·49	·715	·848	·438	·68	·807	·943	·375
·50	·718	·858	·434	·69	·815	·945	·370
·51	·720	·865	·432	·70	·822	·948	·365
·52	·722	·873	·430	·71	·830	·950	·360
·53	·725	·880	·428	·72	·840	·952	·355
·54	·729	·886	·425	·73	·847	·955	·350
·55	·733	·892	·422	·74	·855	·957	·345
·56	·738	·900	·420	·75	·863	·959	·340
·57	·742	·904	·416	·76	·870	·960	·333
·58	·746	·908	·413				

TO CALCULATE THE POSITION OF THE CENTRE OF GRAVITY OF A SHIP'S HULL.

To find the centre of gravity of a ship's hull relatively to any fixed plane (see p. 90).

RULE.—Find the moments of the component parts of the ship's hull relatively to the given plane by multiplying the weight of each part by the perpendicular distance of its centre of gravity from that plane; then find the resultant of those moments by adding together separately the positive and negative moments (or right- and left-handed moments), and taking the difference between the two sums; the resultant will be positive or negative, according to which moments are the greater. Divide the result thus found by the total weight of the hull of the ship; the product will be the perpendicular distance of the centre of gravity from the given fixed plane.

As the centre of gravity of the hull of a ship is generally in the middle line, it is only necessary, as a rule, to determine its position relatively to two fixed planes, one being a transverse vertical plane and the other a horizontal plane, the midship transverse section and the load water-plane being generally taken as the two respective planes.

To determine the position of the centre of gravity of the bottom plating of a ship's hull when of a uniform thickness throughout.

1. *Determine its longitudinal position from a transverse vertical plane as follows* (see p. 89):—

RULE.—Measure the half-girths of the plating at equidistant stations, as if for measuring its area; integrate by means of a set of Simpson's multipliers, and add the results together; then multiply each of those functions of the half-girths in their consecutive order by the figure representing the number of intervals it is from the plane of moments. Find the resultant of those moments and divide it by the sum of the functions of the half-girths, and multiply the product by the common interval between the stations. The result will be the perpendicular distance of the centre of gravity from the given fixed plane.

2. *Determine its perpendicular distance from a fixed horizontal plane by the following rule, providing that all the centres of gravity of the half-girths are below the plane of moments* (see p. 89):—

RULE.—Measure the half-girths as before; integrate them by means of the same set of Simpson's multipliers, and add the results together; then multiply each of those functions of the half-girths in their consecutive order by the respective distance of its centre of gravity from the given plane; add together the products and divide the result by the sum of the functions of the half-girths: the result will be the perpendicular distance of the centre of gravity from the horizontal plane.

N.B. When the frames of a ship are of a uniform character, and are placed at equidistant intervals, their common centre of gravity may be determined in the same way by means of the two foregoing rules.

Table showing Method of Calculating the Longitudinal Position of the Centre of Gravity of the Bottom Plating of a Ship's Hull.

No. of Stations	Half-girths	Simpson's Mults.	Functions of Half-girths	Mults. for Moments	Products for Moments	No. of Stations
1	21·0	1	21·0	8	168·0	1
2	27·2	4	108·8	7	761·6	2
3	30·8	2	61·6	6	369·6	3
4	34·6	4	138·4	5	692·0	4
5	38·8	2	77·6	4	310·4	5
6	41·5	4	166·0	3	498·0	6
7	42·6	2	85·2	2	170·4	7
8	44·0	4	176·0	1	176·0	8
9	44·0	2	88·0	0	·0	9
10	44·0	4	176·0	1	176·0	10
11	43·3	2	86 6	2	173 2	11
12	42·1	4	168·4	3	505·2	12
13	40·3	2	80·6	4	322·4	13
14	38·1	4	152·4	5	762·0	14
15	36·0	2	72·0	6	432·0	15
16	35 0	4	140·0	7	980·0	16
17	32·0	1	32·0	8	256·0	17

Sum of functions of half-girths 1830·6 — 1830·6) 460·8

·246

15

Distance of C. of Grav. towards No. 17 from No. 9 Station 3·690

Table showing Method of Calculating the Vertical Position of the Centre of Gravity of the Bottom Plating of a Ship's Hull.

No. of Stations	Half-girths	Simpson's Mults.	Functions of Half-girths	Mults. for Moments	Products for Moments	No. of Stations
1	21·0	1	21·0	·60	12·60	1
2	27·2	4	108·8	1·25	136 00	2
3	30·8	2	61·6	1·80	110·88	3
4	34·6	4	138·4	2·10	290·64	4
5	38·8	2	77·6	2·25	174·60	5
6	41·5	4	166·0	2·30	381·80	6
7	42·6	2	85·2	2·35	200·22	7
8	44·0	4	176·0	2·40	422·40	8
9	44·0	2	88·0	2·41	212·08	9
10	44·0	4	176·0	2·41	424·16	10
11	43·3	2	86·6	2·40	207·84	11
12	42·1	4	168·4	2·35	395·74	12
13	40·3	2	80·6	2·30	185·38	13
14	38·1	4	152·4	2·25	342·90	14
15	36·0	2	72·0	2·05	147·60	15
16	35·0	4	140·0	1·50	210·00	16
17	32·0	1	32·0	·75	24·00	17
			1830·6		1830·6) 3878·84	

Distance of Centre of Gravity below Longitudinal Plane 2·118

TABLE SHOWING METHOD OF CALCULATING THE POSITION OF THE CENTRE OF GRAVITY OF A SHIP FULLY EQUIPPED.

Items	Weight of Items in Tons	Horizontal Distances		Horizontal Moments		Weight of Items in Tons	Vertical Distances		Vertical Moments	
		Before	Abaft	Before	Abaft		Above	Below	Above	Below
Water, including tanks	14·0	36·0	—	504·0	—	14·0	—	1·3	—	18·2
Provisions, spirits, &c.	8·0	48·0	—	384·0	—	8·0	—	9·0	—	72·0
Officers' stores and slops	5·0	64·0	—	320·0	—	5·0	—	8·0	—	40·0
Officers, men, and effects	30·0	17·0	—	510·0	—	30·0	7·0	—	210·0	—
Masts, yards, and spars	13·2	12·5	—	165·0	—	13·2	33·6	—	443·52	—
Rigging, blocks, and sails	10·8	14·0	—	151·2	—	10·8	30·0	—	24·00	—
Bower anchor	3·5	80·0	—	280·0	—	3·5	17·0	—	59·5	—
Stream anchor	·6	—	69·0	—	41·4	·6	17·0	—	10·2	—
Bower cable	20·0	44·0	—	880·0	—	20·0	—	10·0	—	200·0
Stream cable	2·0	—	70·0		140·0	2·0	—	8·0		16·0
Boats, four in number	3·25		49·0	—	159·25	3·25	17·0	—	55·25	—
Warrant officers' stores, &c	2·0	68·0	—	136·0	—	2·0		1·0	—	2·0
Two 18-ton guns with carriages and slides	56·0	26·0		1456·0	—	56·0	9·0		504·0	—
One 6½-ton gun with carriage and slide	10·0		90·0	—	900·0	10·0	13·0		130·0	—
Four 9-pounder guns with carriages	2·5		20·0	—	50·0	2·5	11·0	—	27·5	—
Shot, shell, and powder	60·0	15·0	—	900·0		60·0		8·0	—	480·0
Small arms and spare stores	3·0	25·0		75·0	—	3·0		9·0	—	27·0
Engines, boilers, water, and spare gear	470·0		29·0	—	13630·0	470·0		6·2	—	2914·0
Coals for boilers	250·0	16·0		4000·0	—	250·0		4·0	—	1000·0
Coals for galley	30·0	11·0	—	330·0	—	30·0	4·0	—	120·0	—
Wood, sand, &c.	2·0	40·0		80·0	—	2·0		6·0	—	12·0
Cement in bottom of hull	25·0	84·0	—	2100·0	—	25·0	—	15·0	—	375·0
Hull, iron and w	850·0	2·82	—	2397·0		850·0		·85	—	722·5
Iron armour to	297·20		·56		166·81	297·20	—	·56	—	166·43
Wood backing t	47·84		4·42		211·45	47·84	—	1·10		52·62
Iron armour to	239·40	23·3	—	2345·7		239·40	7·80	—	1868·97	—
Wood backing t	28·74	19·6		563·30		28·74	7·63	—	219·29	

Total 2464·09 Mom. before No. 54 Sta. 20577·2 | 15390·71 | 2464·09 Mom. above L. W. L. 3913·23 | 6100·80

" abaft " 15390·71 | 3913·23

Total of weights 2464·09) 5186·49 | Total of weights 2464·09) 2187·57

Distance of Centre of Gravity before No. 54 station . 2·105 | Distance of Centre of Gravity below L. W. L. . ·888

Metacentre above L. W. L. . 1·580

Height of Metacentre above Centre of Gravity 2·468

Horizontal Moments taken about No. 54 Station. Vertical Moments taken about Load Water-line. Centre of buoyancy before No. 54 Station = 2·105.

STABILITY.

STATICAL STABILITY.

Statical stability is defined to be the moment of force by which a floating body endeavours to gain its upright position, or position of equilibrium, after having been deflected from it.

FIG. 144.

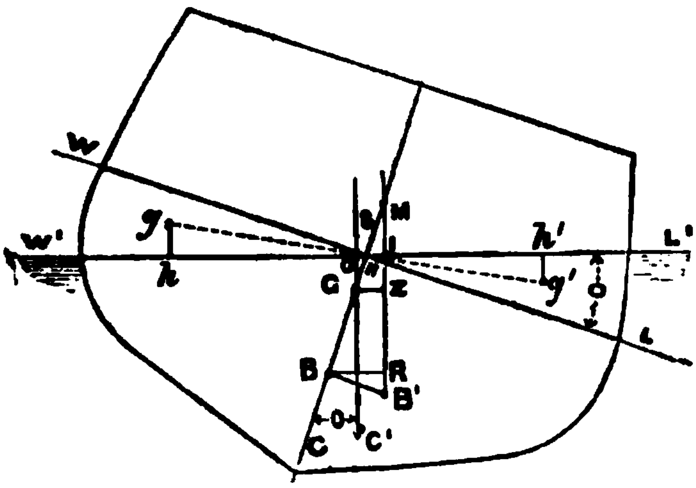


Fig. 144 is a transverse section of a ship heeled over through a certain angle θ. W′L′ is the water-line for the inclined position, and WL is the water-line for the upright position. These two planes intersect each other in a longitudinal direction, and bound two wedges L′SL and WSW′ equal in volume to each other, provided the displacement remains the same. The wedges are called respectively the wedges of *immersion* and *emersion*, or the *in* and *out* wedges. G is the centre of gravity of the ship, and B′ her centre of gravity of displacement, or centre of buoyancy. The weight of the ship then acts vertically downwards through G, and the resultant pressure of the water acts vertically upwards through B′, these two forces forming a *righting couple*, the arm of which is GZ—that is, the perpendicular distance between the lines of action of the two forces. The moment of this couple—that is, the weight of the ship, or its displacement, multiplied by the length of the arm GZ—is the *moment of statical stability* of the ship at the given angle of inclination θ. This moment is generally expressed in *foot tons*—that is, the weight of the ship in tons multiplied by the length of the arm GZ in feet. B is the centre of buoyancy of the ship when upright; S is the point of intersection of the two water-lines, I the point where the vertical B′M cuts the plane of flotation; g and g' are the centres of gravity of the emerged and immersed wedges respectively, gh and $g'h'$ being perpendiculars dropped to g and g' from the plane of flotation W′L′. The point M, where the vertical line BM, drawn through the centre of buoyancy B when the ship is in an upright position, cuts the vertical line B′M, drawn through the centre of buoyancy B′ for the inclined position, is termed the *transverse metacentre* when the ship is inclined through an indefinitely small angle, and also when the point of intersection is the same for all angles of heel.

When the position varies for the different angles of heel, it is termed a *shifting metacentre*.

When the ship is inclined longitudinally, it is called the *longitudinal metacentre*.

During the inclination of the ship the centre of buoyancy moved from B to B′, and B′ lies in a plane parallel to a line joining g and g'. The distance BB′ can be found from the following expression:—

$$BB' = \frac{V \times gg'}{D},$$

where D = volume of displacement and V = volume of either of the wedges;

$$BR = \frac{V \times hh'}{D}, \text{ where BR is perpendicular to } B'M;$$

and $$GZ = BR - BG \cdot \sin\theta = \frac{V \times hh'}{D} - BG \cdot \sin\theta,$$

whence Atwood's formula for expressing the *moment of statical stability* at any angle θ is

$$M = (V \times hh') - (D \times BG \cdot \sin\theta)$$
$$= D\left\{\frac{(V \times hh')}{D} - (BG \cdot \sin\theta)\right\}.$$

The moment of *statical surface stability* at any angle θ is BR × D, being what the righting moment would be, supposing the centre of gravity of the ship coincided with B. The angle of heel in fig. 144 is BMB′ = LSL′, and its sine is equal to $\frac{BR}{BM} = \frac{GZ}{GM}$.

The *coefficient* of a ship's stability at any angle of heel is expressed when the displacement is multiplied by the vertical height of the metacentre for the given angle of heel above the centre of gravity.

That is, the coefficient of a ship's stability at any angle θ

$$= D \times GM = D(BM - BG)$$

$$BM = \frac{V \times hh'}{D \cdot \sin\theta}.$$

BR is said to be the *lever of statical surface stability.*

When M lies above G the vessel is *stable*; if too high, the vessel is *uneasy*; when below, the vessel is *unstable*; and when it coincides with G, the equilibrium is said to be *neutral.*

The point M in vessels of the common type is usually calculated for the upright position, as it generally remains a fixed point for the first 10 or 15 degrees of heel, when it is useful for comparing the *initial surface stability* of different vessels.

To calculate the height of the metacentre above the centre of buoyancy see pp. 82 and 106.

Dynamical Stability.

Dynamical stability is defined to be the amount of mechanical work necessary to cause a body to deviate from its upright position, or position of equilibrium.

Dynamical stability is expressed as a moment by multiplying the sum of the vertical distances through which the centre of gravity of the ship ascends and the centre of buoyancy descends, in moving from the upright to the inclined position, by the weight of the ship, or displacement.

In fig. 144 during the inclination of the ship through the angle θ, the centre of gravity has been moved through a vertical height $GH - GO$, and the centre of buoyancy has been lowered through a vertical distance $B'I - BH$, and the whole work to do this, or her moment of dynamical stability for the given angle θ, is

$$= D\{(GH - GO) + (B'I - BH)\}$$
$$= D(B'Z - BG) = D(B'R - BG \cdot \text{vers }\theta)$$
$$= D\left(\frac{V(gh + g'h')}{D} - BG \cdot \text{vers }\theta\right);$$

whence Moseley's formula for the moment of dynamical stability at any angle θ is

$$= V(gh + g'h') - (D \times BG \cdot \text{vers }\theta).$$

The dynamical stability of a ship at any angle θ is the *integral* of its statical stability at the given angle—that is, if M = the statical stability and U the dynamical stability, then

$$U = \int M d\theta,$$

where $d\theta$ is a very small angle of heel.

The *moment of dynamical surface stability* is expressed by multiplying the weight of the ship, or displacement, by the depression of the centre of buoyancy during the inclination—that is, for the angle θ

$$U = D(B'I - BH).$$

Rules connected with Stability.

1. *To find approximately the moment of statical surface stability per foot of length of a vessel at any small angle of heel.*

Rule.—Cube the half-breadth of the vessel and multiply it by the sine of the angle of heel; two-thirds of the product will be the required result.

This result is expressed as follows when B = half-breadth of vessel:—

$$\tfrac{2}{3}(B^3 \times \sin\theta).$$

2. *To find approximately the surface stability of a vessel for any small angle of heel.*

Rule.—Divide the moment of inertia of the plane of flotation for the upright position relatively to the middle line by the volume of displacement; the quotient multiplied by the sine of the angle of heel will be the required result.

Or it may be expressed more fully as follows:—

Divide the length of the plane of flotation, or water-line, for the upright position into a number of equal intervals,

and measure the half-breadths at the points of division; cube those half-breadths and treat them as if they were ordinates of a new curve of the same length as the plane of flotation: two-thirds of the area of the new curve, found by a proper rule, will be the moment of inertia of the plane of flotation relatively to the middle line. This moment of inertia multiplied by the sine of the angle of heel will be the required result. It is usually expressed in algebraical symbols thus:—

$$\frac{2 \sin \theta}{3} \int y^3 dx.$$

Note.—The two foregoing rules are exact for any angle of heel if the metacentre remains fixed for the different angles, and therefore remains also true for any angle of heel when the moment of inertia of the plane of flotation due to the angle of heel can be found.

3. *To find the height of the metacentre above the centre of buoyancy for the upright position.*

RULE.—Divide the moment of inertia of the plane of flotation relatively to the middle line by the volume of the displacement.

In algebraical symbols it is expressed as follows:—

$$\text{BM} = \frac{\frac{2}{3} \int y^3 dx}{\text{D}}.$$

Note.—For moment of inertia see Rule 2, p. 93, also p. 61.

4. *To find approximately the dynamical stability of a vessel at any given angle of heel.*

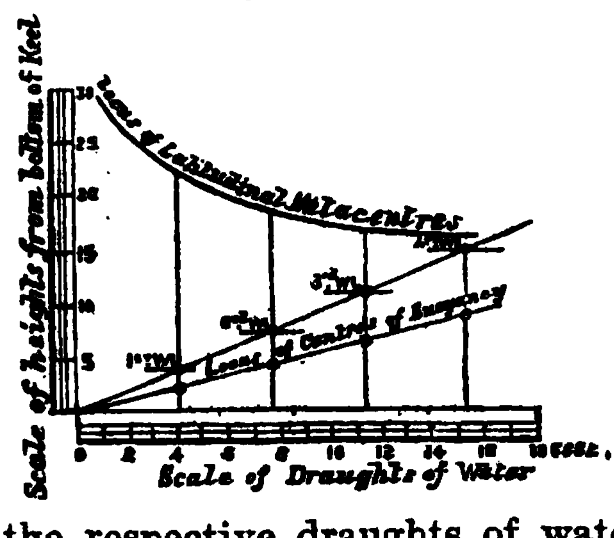
RULE 1.—Multiply the displacement by the height of the metacentre above the centre of gravity, and that product by the versed sine of the angle of heel.

RULE 2.—Multiply the statical stability for the given angle by the tangent of one-half of the angle of heel.

CURVES OF STABILITY.

The Metacentric Curve, or Curve of Metacentres, is a curve used to determine approximately the initial statical surface stability a vessel has at any draught of water parallel to her constructed load draught.

FIG. 145.



Method of Construction.—Calculate the height of the ship's metacentre from the under side of keel for several successive draughts of water parallel to her constructed load draught; set those heights off as ordinates (see fig. 145) from a base line the abscissæ of which represent to scale the respective draughts of water: a curve bent through the extremities of these ordinates will form the metacentric curve.

The Curve of Statical Stability is a curve used to determine the exact statical stability of a vessel at any given angle of heel.

FIG. 146.

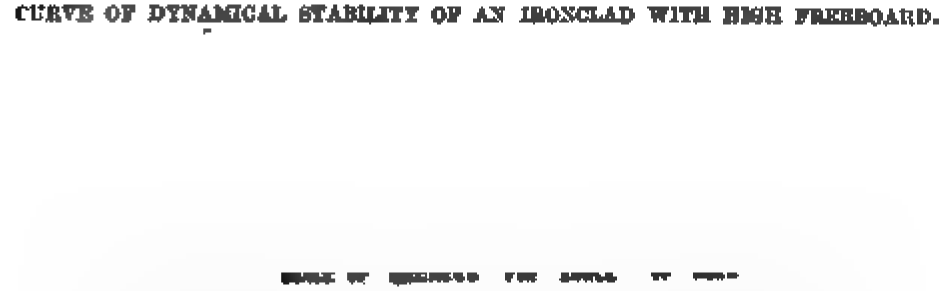
CURVE OF STATICAL STABILITY OF AN IRONCLAD WITH HIGH FREEBOARD.

Method of Construction.—Calculate the length of the arm of the righting couple, or GZ (see fig. 144), for several successive angles of heel taken between the upright position and that at which the length of the arm becomes zero; set the lengths of these arms off as ordinates (see fig. 146) from a base line the abscissæ of which represent to scale the respective angles of heel· a curve bent through the extremities of these ordinates will form a curve of statical stability.

The Curve of Dynamical Stability is constructed in a similar manner to that of the curve of statical stability, with the exception that the various lengths of the arm $(B'Z - BG) = (B'R - BG \text{ vers } \theta)$, (see fig. 144), are taken as ordinates instead of GZ.

FIG. 147.

CURVE OF DYNAMICAL STABILITY OF AN IRONCLAD WITH HIGH FREEBOARD.



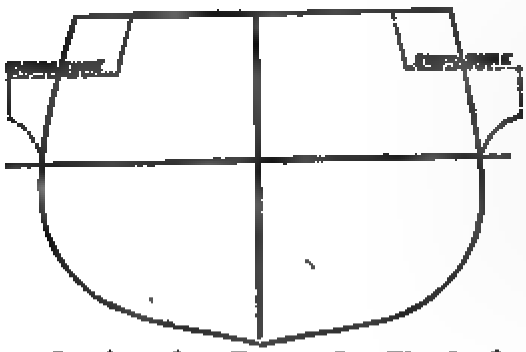
Curves of Statical and Dynamical Surface Stability are also constructed in a similar manner to the foregoing curves, the lengths of the arms BR and $B'I - BH$ (see fig. 144) being taken as ordinates for the respective curves.

TO CALCULATE THE STATICAL AND DYNAMICAL STABILITIES OF A VESSEL AT SUCCESSIVE ANGLES OF HEEL.

1. *Body Plan* (fig. 149).—Prepare a body plan in which all the sections are taken perpendicular to the load water-line, and at equal distances apart. In constructing it the sections should be made fair continuous curves, any irregularities

which might be caused by embrasures, &c., being left out (as shown in full lines in fig. 148, where the dotted lines show the actual section of vessel), they being treated separately afterwards as *appendages*. When there are appendages it is also necessary to have correct sheer and half-breadth draughts, in order to calculate their volume, &c.

Fig. 148.



2. *Angular Interval.*—The body plan has now to be crossed by a number of lines, radiating from the middle point of the load water-plane, and at equiangular intervals, taking care that one passes through the edge of the upper continuous deck amidships.

Fig. 149.

The equiangular interval is determined as follows:—Divide the angle which the radiating line, passing through the edge of the upper deck, makes with the load water-line, into such a number of equiangular intervals that the line passing through the edge of the upper deck becomes a stop-point in the integration to which these radiating lines will be afterwards treated. If Simpson's first rule is used the number of intervals must be even; if his second rule, a multiple of three must be used, and so on. The angular interval should not be more than 10° or less than 3°.

It is usual to introduce an intermediate radiating line at half an interval after the edge of the deck has been passed, in order to reduce the error caused by applying Simpson's rule to so irregular a surface as the upper deck.

3. *Measuring the Ordinates.*—The ordinates of the immersed and emerged sides of the various inclined longitudinal water-planes are measured off right fore and aft for each successive angle of heel from the middle line of the ship, and entered upon a set of tables, styled *preliminary tables*, under their proper heading. One of these tables is necessary for each separate angle of heel.

4. *Preliminary Tables* (see p. 107).—Three operations are performed upon the ordinates entered in these tables. Firstly, they are affected by a set of Simpson's multipliers, in order

to find a function for the *area* of the immersed and emerged sides of the respective radial planes. Secondly, the squares of the ordinates are affected by the same set of multipliers in order to find a function for the *moment* of the immersed and emerged sides of the respective radial planes. Thirdly, the cubes of the ordinates are affected by the same set of multipliers in order to find a function for the *moment of inertia* of the immersed and emerged sides of the various radial planes about the middle line of ship.

5. *Combination Tables* (see p. 108).—The results obtained in the preliminary tables are made use of in these tables to determine—

(1st) The area of the various inclined water-planes, together with their centres of gravity.

(2nd) The volumes of the assumed wedges of immersion and emersion.

(3rd) The position of the true water-planes at the different angles of heel.

(4th) The moments of the corrected wedges of immersion and emersion.

6. *Areas of the Inclined Water-planes.*—The area of an inclined water-plane is easily found for any angle of heel by adding together the sums of the functions of the ordinates for the immersed and emerged sides of the respective water-planes, and multiplying the result by $\frac{1}{3}$ the longitudinal interval if Simpson's first rule is used.*

7. *Centre of Gravity of the Inclined Water-planes.*—To find the distance of the centre of gravity of any inclined water-plane relatively to the middle line of the ship, proceed as follows: —Take the difference between the sums of the functions of the squares of the ordinates for the immersed and emerged sides of the water-plane; divide the result by 2 and multiply the quotient by $\frac{1}{3}$ the longitudinal distance between the ordinates, if Simpson's first rule is used. That product divided by the area of the water-plane will give the distance of its centre of gravity from the middle line.

8. *Volumes of Assumed Wedges.*—Take the sums of the functions of the squares of the ordinates for both sides of each of the radial planes contained in the wedges of immersion and emersion, and enter them in their proper column in the combination table, and affect them by a proper set of multipliers; add their results together, subtract the lesser sum from the greater, and divide the result by 2. The quotient multiplied by $\frac{1}{3}$ the longitudinal distance between the ordinates, if Simpson's first rule is used (this division by 3 is generally done in the preliminary tables): this final product multiplied by $\frac{1}{3}$ of the equi-angular interval in circular measure, if Simpson's first rule is again

* *Note.*—The division by 3 is generally done in the preliminary tables.

used, will give the difference between the volumes of the assumed wedges of immersion and emersion. If there are any appendages the necessary additions or deductions are made here.

9. *Correcting Layer.*—If the volume of the assumed wedge of immersion exceeds that of the wedge of emersion, it shows that the displacement up to the radial plane is too great, and that to find the true water-plane a parallel layer must be taken away from the assumed wedges; but if the wedge of emersion exceeds that of immersion, a parallel layer must be added to the wedges.

The *thickness* of this layer is found by dividing the difference between the volumes of the two assumed wedges by the area of the proper radial water-plane, having made any additions or deductions in the case of appendages.

10. *Moments of Wedges for Statical Stability.*—The sums of the functions of the cubes of the ordinates for both the immersed and emerged wedges are placed in the proper column in the combination table, and are affected by the same set of multipliers as were determined for the sums of the functions of the squares; the products are multiplied by the various cosines of the angles of inclination made by the radial planes with the load water-line; the products are then added together and the sum divided by 3; the quotient is then multiplied by $\frac{1}{3}$ the angular interval, and that product by $\frac{1}{3}$ the longitudinal interval, between the ordinates, if Simpson's first rule has been used (this division by 3 is generally done in the preliminary tables): the final result will be the moment of the wedges about a line perpendicular to the radial plane, and passing through the middle point of the load water-plane. The corrections for the moments of the appendages must now be added or subtracted, as the case may be, also the correction for the layer, if any, must be done here, its moment being found by multiplying its volume by the distance of the centre of gravity of its water plane from the middle point of the load water-plane. If the centre of gravity of the layer lies towards that side for which the assumed wedge is the greater, the correction must be deducted; if it lies towards the opposite side, it must be added. This final result, being divided by the total volume of displacement, will give the length of the arm BR (see fig. 144). Multiply the height of the centre of gravity above the centre of buoyancy by the sine of the angle of heel, and subtract the product from BR; the remainder will be the length of the arm of the righting couple GZ; GZ multiplied by the displacement in tons will give the righting moment, or statical stability, of the ship for the given angle of heel.

11. *Moments of the Wedges for Dynamical Stability.*—This result is determined in a manner somewhat similar to that pursued for the statical stability, the only difference being that the

sums of the functions of the cubes are multiplied by the sines of the various angles of inclination instead of the cosines; the sum of the products so obtained being divided and multiplied by the same numbers as were used for the statical stability, in order to find the moment of the wedges uncorrected relatively to the respective radial planes. The corrections for the appendages are then made, that for the correcting layer being subtracted in all cases. The moment for the correcting layer is found by multiplying its volume by half its thickness, that being about the vertical height of its centre of gravity from its radial plane. This final result divided by the total volume of displacement will give the length of the arm B′R, from which if BG . vers θ be deducted, the remainder will equal the length of the arm for the dynamical stability, or the vertical height through which the centre of gravity of the ship has been lifted and the centre of buoyancy depressed.

12. *Geometrical Mode of Calculating Dynamical Stability.*—The dynamical stability of a vessel at any given angle of heel is the sum of the moments of the statical stability taken at indefinitely small equiangular intervals up to the given angle of heel, and is therefore equal to the area of the curve of statical stability included between the origin of the curve and the angle in question. It must be noticed that the abscissæ of a curve of statical stability is given in angles, and therefore the longitudinal interval is taken in circular measure.

But, as the lengths of the arms for statical stability are generally used to construct a curve instead of the moments of stability, the area, as above found by the rule from such a curve, will necessarily give the length of the *arm* for dynamical stability and not the *moment*.

Example (see fig. 146).—To find the length of the arm for dynamical stability at an angle of 30° inclination.

Angles of Heel	Lengths of Statical Levers GZ	Simpson's Multipliers	Products
0 degrees	·0	1	·0
5 "	·2	4	·8
10 "	·42	2	·84
15 "	·68	4	2·72
20 "	·97	2	1·94
25 "	1·30	4	5·20
30 "	1·66	1	1·66
			13·16

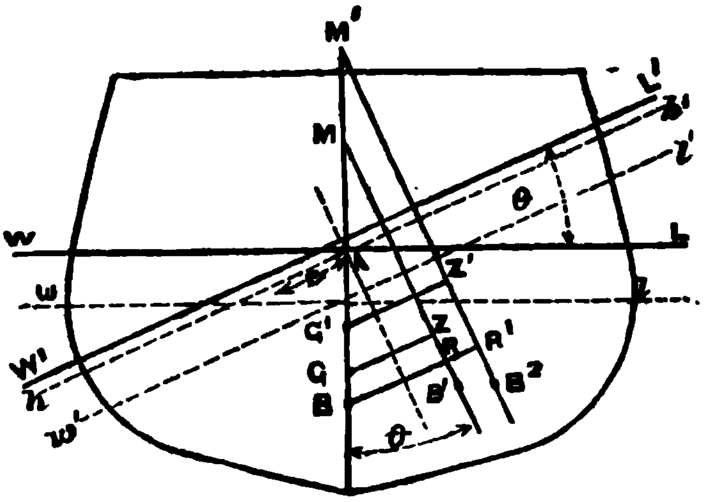
$\frac{1}{3}$ of angular interval in circular measure = ·0291

1316
11844
2632

Dynamical lever for 30° = ·382956

13. *Curve of Stability for Light Draught.*—The lengths of the arms for this curve can readily be approximated from the results obtained for the curve in the load condition.

FIG. 150.



In fig. 150 WL is the load water-line, and *wl* the light water-line, for the upright position of the vessel. If the vessel is inclined through an angle θ, and W'L' is the true position of the inclined water-plane for the load condition, then the true position of the water-plane for the light condition will run parallel to it, as $w'l'$. To determine its perpendicular distance from W'L', divide the volume of the layer contained between the light and load water-planes by the area of the assumed inclined water-plane hh', which was found for the inclined load condition. Let B be the centre of buoyancy for the upright load condition, B' for the inclined load condition, and B² for the inclined light condition. BR is perpendicular to the vertical B'M, and BR' is perpendicular to the vertical B²M'.

Let D equal volume of light displacement.
„ d = volume of displacement contained between the light and load water-planes.
„ c = distance of centre of gravity of assumed inclined water-plane from the vertical through A.
„ GZ and G'Z' = the lengths of the arms of the righting couples for the load and light condition respectively.

$$\text{Then } RR' = \frac{d\{c + (BR - BA \, . \, \sin\theta)\}}{D} \qquad BR' = BR + RR',$$

$$\text{and } G'Z' = BR' - BG' . \sin\theta.$$

Surface of Flotation.—If a ship be inclined through an unlimited number of indefinitely small angles in every possible direction, a curved surface touching all the planes of flotation thus made is called a surface of flotation, and the point of its contact with any water-plane is the centre of gravity of that plane.

Axis of Level Motion.—When the transverse section of a surface of flotation is a circle, the centre of that circle is termed the axis of level motion. This axis lies parallel to the load water-line, and is in the longitudinal middle-line vertical plane of the ship for the upright position, and is so placed as to

keep the same position, when the vessel is heeled over to any angle, as when she was upright.

To determine approximately the height of the axis of level motion above the plane of flotation.

RULE.—Measure the angles of inclination of the several cross sections to the vertical between wind and water, and find their tangents, distinguishing those tangents respectively into positive and negative, according as the side of the section inclines outward or inward (that is, having any flare or tumble-home); multiply the tangents by the squares of the half-breadths of the cross sections to which they belong, and the products by a set of Simpson's multipliers in their consecutive order; take the difference between the sums of the positive and negative products, and multiply the difference by $\frac{1}{3}$ the longitudinal interval (if Simpson's first rule is used), and divide the product by half the area of the water-plane: the quotient will be the required result.

LONGITUDINAL METACENTRE AND ALTERATION OF TRIM.

To determine the vertical height of the longitudinal metacentre above the centre of buoyancy.

RULE.—Divide the moment of inertia of the load water-plane, relatively to a transverse axis passing through the centre of the plane of flotation, by the volume of displacement. (For example of calculation see p. 214.)

The following method will generally be found in practice to be the simplest for finding the moment of inertia of the plane of flotation relatively to the transverse axis through the plane of flotation:—First determine the moment of inertia of the given plane relatively to one of its ordinates as a transverse axis (see Rule 7, p. 61); then from the result subtract the area of the plane multiplied by the square of the distance of its centre from the given axis.

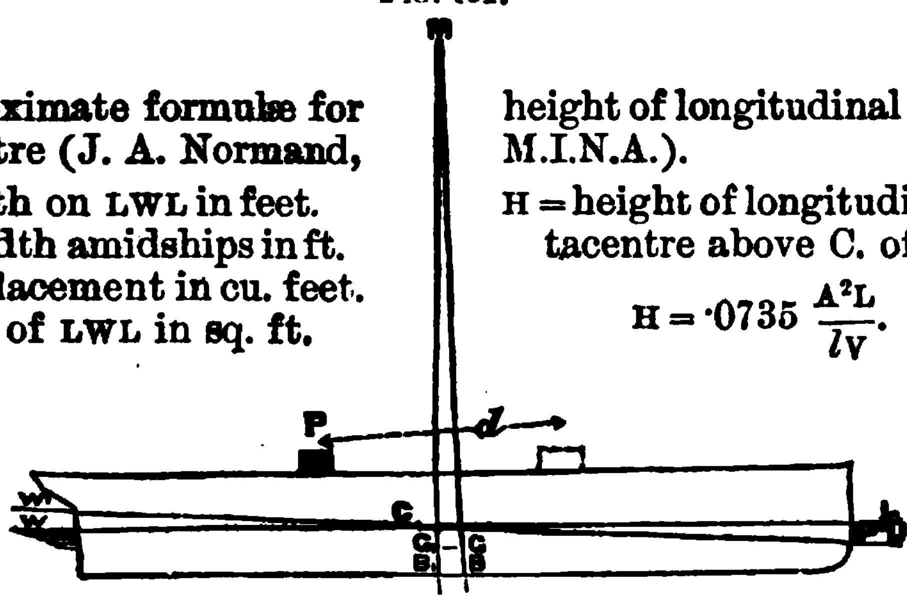
FIG. 151.

Approximate formulæ for height of longitudinal metacentre (J. A. Normand, M.I.N.A.).

L = length on LWL in feet.
l = breadth amidships in ft.
V = displacement in cu. feet.
A = area of LWL in sq. ft.

H = height of longitudinal metacentre above C. of Buoy.

$$H = \cdot 0735 \frac{A^2 L}{l V}.$$



Moment to Alter the Trim of a Vessel.—In fig. 151 let WL be the original load water-line, W′L′ the load-line to which it is

required to trim the vessel, C the centre of flotation and the point at which the two load-lines intersect each other.

The total alteration of trim $= WW' + LL'$.

Let G be the position of the centre of gravity, B the centre of buoyancy, for the upright position, G′ and B′ the altered positions of the centres due to the alteration in trim, and M the longitudinal metacentre; let P = the weight on board that has to be moved, d = the horizontal distance through which the weight has to be moved to produce the required trim, and D = the displacement of the ship in tons: then

$$BB' = \frac{(WW' + LL')BM}{WL}, \quad GG' = \frac{(WW' + LL')GM}{WL} = \frac{P \times d}{D};$$

also $WW' = \frac{WC(P \times d)}{GM \times D}$, $LL' = \frac{LC(P \times d)}{GM \times D}$, and $WW' + LL' = \frac{WL(P \times d)}{GM \times D}$.

Let $WW_1 + LL_1 = 1$ inch; then $\frac{WL(p \times d)}{GM \times D} = \frac{1}{12}$.

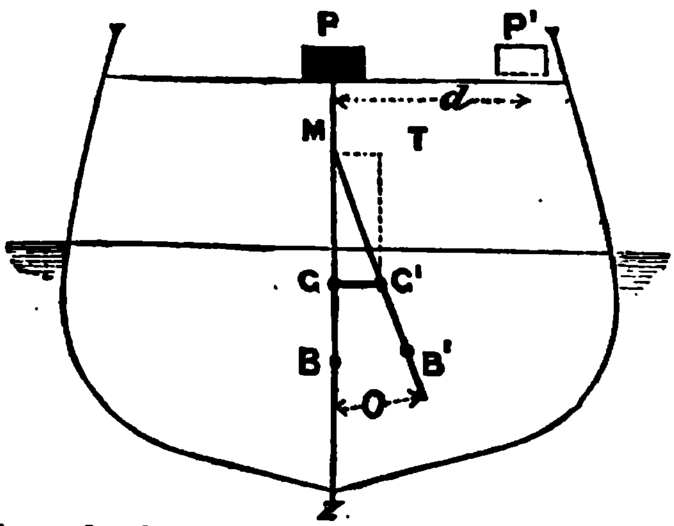
$$\therefore \text{Moment to alter trim one inch} = \frac{D}{12} \times \frac{GM}{WL}.$$

$$\text{Moment to alter trim } n \text{ inches} = n \times \frac{D}{12} \times \frac{GM}{WL}$$

Note.—All the measurements are taken in feet.

To Determine the Vertical Position of a Ship's Centre of Gravity by Experiment.

FIG. 152.



In fig. 152 let MZ be the upright axis of a ship; her centre of gravity then lies somewhere in that axis. M is the metacentre, and GM its vertical height above the centre of gravity G.

If a weight P be moved transversely through a distance $PP' = d$, it will heel the vessel over through an angle θ, and her centre of gravity will then shift in a direction GG′ parallel to that in which the centre of gravity of the weight has been shifted. Let MT be parallel to GG′ and TG′ parallel to GM; let P = weight shifted in tons, and D = displacement of ship in tons: then

$$MT = GG' = \frac{P \times d}{D}, \text{ and } GM = GG' \cot \theta = \frac{P \times d}{D} \cot \theta.$$

Note.—If several weights are shifted the total sum of each of the moments must be taken.

PROOF OF RULE FOR FINDING TRANSVERSE METACENTRE. (FIG. 153.)

Let the angle of inclination $\text{WSW}_1 = \theta$ be indefinitely small.

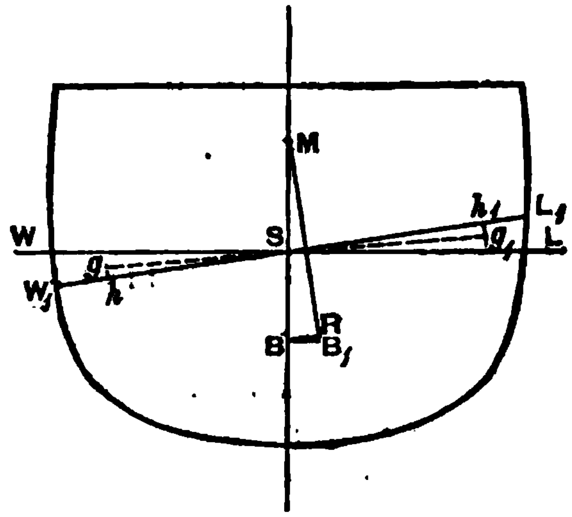
$y = \text{WS}$ or SL.

$v_1 =$ area of wedge WSW_1 or LSL_1.

$v =$ volume of WSW for whole length of ship.

$\text{V} =$ volume of displacement.

FIG. 153.



Then $\quad v_1 = \dfrac{\text{SL} \times \text{LL}_1}{2}$, but $\text{LL}_1 = \text{SL} \sin\theta$ (practically);

$$\therefore v_1 = \frac{\text{SL}^2 \sin\theta}{2}.$$

But $\quad \text{S}h_1 = \dfrac{2}{3}\,\text{SL}$; $\therefore hh_1 = \dfrac{4}{3}\,\text{SL}$ when θ is indefinitely small.

Now
$$v_1 \times hh_1 = \frac{4}{3}\text{SL} \times \frac{1}{2}\text{SL}^2 \sin\theta,$$
$$= \frac{2}{3}\sin\theta \times \text{SL}^3;$$
$$\therefore v \times hh_1 = \frac{2}{3}\int y^3 \sin\theta\, dx.$$

But $\quad v \times hh_1 = \text{V} \times \text{BR}$, and $\text{BR} = \text{BM} \sin\theta$;

$$\therefore \text{V} \times \text{BM} \sin\theta = \frac{2}{3}\int y^3 \sin\theta\, dx;$$
$$\therefore \text{BM} = \frac{2}{3}\int \frac{y^3 dx}{\text{V}}.$$

If the transverse sections are of circular form (fig. 154) in the vicinity of the water-line, then, in the act of heeling, the part below the circular section remains under water, and so may be neglected.

Now the section WPL is moved to W_1QL_1.

Hence required moment of surface stability is equal to the difference in moments of segments WPL and W_1QL_1 about axis $MQ = BR \times V = BM \times V \times \sin\theta$.

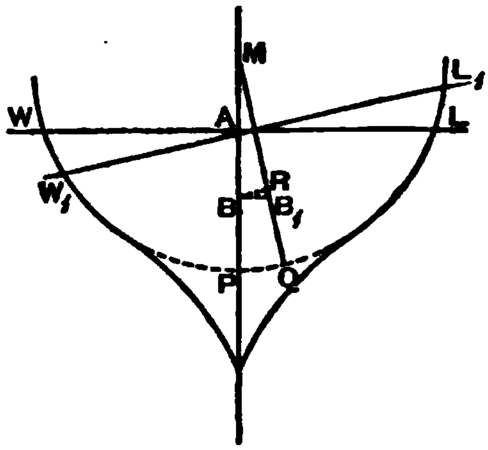


FIG. 154.

But moment of segment W_1QL_1 is zero, and moment of segment WPL $= \frac{2}{3} AW^3 \sin\theta$.

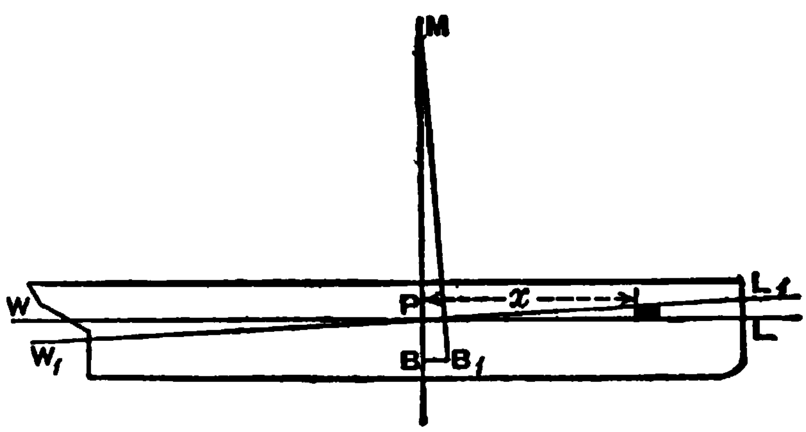
$\therefore$ moment for whole length of ship $= \frac{2}{3}\int y^3 \sin\theta\, dx$.

And, as before, $V \times BM \sin\theta = \frac{2}{3}\int y^3 \sin\theta\, dx$. $\quad \therefore BM = \frac{2}{3}\int \frac{y^3 dx}{V}$.

PROOF OF RULE FOR FINDING LONGITUDINAL METACENTRE. (FIG. 155.)

Let x = distance of section ▬ from centre of gravity L.W. plane.
$2y$ = distance across ship at section ▬ and dx = its width.
θ = angle of inclination water planes (indefinitely small).
V = volume of displacement. v = volume of either wedge.
gg_1 = distance between their centres of gravity.

FIG. 155.



Volume of prism ▬ $= 2y \times x \times dx \times \tan\theta$,

and moment about p $= x \times$ volume $= 2yx^2 \,.\, dx \,.\, \tan\theta$;

$\therefore$ whole moment of wedges $= v \times gg_1 = \int 2yx^2 . dx . \tan\theta$.

But $\qquad v \times gg_1 = V \times BB_1 = V \times BM \tan\theta$ (practically);

$$\therefore \quad V \times BM \tan\theta = \int 2y\, x^2 \,.\, dx \,.\, \tan\theta\,;$$

$$\therefore BM = 2\int \frac{x^2\, y\, dx}{V}.$$

But $2\int x^2\, y\, dx$ = moment of inertia of load water-line plane about its centre of gravity;

$$\therefore BM = \frac{\text{moment of inertia of load water-line plane}}{\text{volume of displacement}}.$$

CALCULATION OF HEIGHT OF LONGITUDINAL METACENTRE ABOVE CENTRE OF BUOYANCY, AND MOMENT TO ALTER TRIM ONE INCH.

Nos. of Ordinates	Ordinates	Simpson's Multipliers	Products for Area	Mults. for Moments	Products for Moments	Mults. for Moments of Inertia	Products for Moments of Inertia	Nos. of Stations
1	·1	½	·05	0	·0	0	·0	1
1½	3·6	2	7·20	½	3·60	½	1·80	1½
2	7·1	1	7·10	1	7·10	1	7·10	2
2½	9·5	2	19·00	1½	28·50	1½	42·75	2½
3	11·6	1½	17·40	2	34·80	2	69·60	3
4	13·7	4	54·80	3	164·40	3	493·20	4
5	14·3	2	28·60	4	114·40	4	457·60	5
6	14·4	4	57·60	5	288·00	5	1440·00	6
7	14·4	2	28·80	6	172·80	6	1036·80	7
8	14·4	4	57·60	7	403·20	7	2822·40	8
9	14·2	2	28·40	8	227·20	8	1817·60	9
10	13·8	4	55·20	9	496·80	9	4471·20	10
11	13·4	1½	20·10	10	201·00	10	2010·00	11
11½	11·1	2	22·20	10½	233·10	10½	2447·55	11½
12	8·4	1	8·40	11	92·40	11	1016·40	12
12½	4·4	2	8·80	11½	101·20	11½	1163·80	12½
13	·2	½	·10	12	1·20	12	14·40	13
			421·35		2569·70		19312·20	
⅓ Long. Interval			5·7		17·1	Long. Int.	17·1	
			2401·695		43941·87		30238·62	
			2			Long. Int.	17·1	
Cu. ft. in a ton 35)			4803·39				5647080·402	
		12)	137·239			Long. Int.	17·1	
Dispt. per inch			11·436			3)	96565074·8742	
							32188358·2914	
							2	

Moment of Inertia about No. 1 Ordinate . 64376716·5828
Area of Load Water-plane × $(104·29)^2$. 52243610·6899
Volume of Displacement in cub. feet 18270) 12133105·8929
Height of Long. Metacentre above Centre of Buoy. 664·1
Height of C. of Grav. of ship above Centre of Buoy. 2·73
Height of Long. Metacentre above C. of G. of ship. 661·37

421·35) 43941·87
Distance of C. of Flotation from No. 1 Ordinate 104·29

Moment to alter trim one inch $= \dfrac{661·37}{205^*} \times \dfrac{522^\dagger}{12} =$ 140·34 foot tons.

* Length of ship at L. W. Line = 205 ft. † Dispt. of ship in tons = 522.

TABLE SHOWING METHOD OF CALCULATING THE HEIGHT OF TRANSVERSE METACENTRE ABOVE CENTRE OF BUOYANCY AT EQUIDISTANT PARALLEL DRAUGHTS OF WATER, IN ORDER TO CONSTRUCT A METACENTRIC CURVE, OR CURVE OF METACENTRES.*

2ND WATER-PLANE

Nos. of Stations	Ords.	Cubes	Mults.	Functs.
1	·2	·00	1	·00
2	2·3	12·16	4	48·64
3	6·4	262·14	2	524·28
4	9·9	970·29	4	3881·16
5	12·3	1860·86	2	3721·72
6	13·5	2460·37	4	9841·48
7	13·8	2628·07	2	5256·14
8	13·7	2571·35	4	10285·40
9	12·8	2097·15	2	4194·30
10	10·6	1191·01	4	4764·04
11	6·4	262·14	2	524·28
12	1·9	6·85	4	27·40
13	·2	·00	1	·00

43068·84
Longitudinal Interval . . 16·6
25841304
25841304
4306884
3)714942·744
238314·248
2
3)476628·496

Vol. of Displ. to 1st Water-plane } 7718·51)158876·165

Metacentre above C. of Buoy. 20·583

Functions of Areas† of Water-planes { 311·4×1=311·4×0= 0 ; 193·8×4=775·2×1=775·2 ‡ ; 7·0×1= 7·0×2= 14·0

Function of vol. of Displ. to 2nd W.P. } 1093·6)789·2

·721

Water-planes apart ½ . . 1·9063

C. of Buoy. below 2nd w. plane 1·3744

3RD WATER-PLANE

Nos. of Stations	Ordinates	Cubes	Mults.	Functions
1	·2	·00	1	·00
2	4·2	74·08	4	296·32
3	9·2	778·68	2	1557·36
4	13·1	2248·09	4	8992·36
5	15·3	3581·57	2	7163·14
6	16·0	4096·00	4	16384·00
7	16·0	4096·00	2	8192·00
8	16·0	4096·00	4	16384·00
9	15·7	3869·89	2	7739·78
10	14·8	3241·79	4	12967·16
11	11·5	1520·87	2	3041·74
12	5·4	157·46	4	629·84
13	·2	·00	1	·00

83347·70
Longitudinal Interval . 16·6
50008620
50008620
8334770
3)1383571·820
461190·606
2
3)922381·212

Vol. of Displ. to 2nd Water-plane } 23420·7)307460·404

Metacentre above C. of Buoy 13·127

Functions of Areas† of Water-planes { 413·1×1= 413·1×0= 0 ; 5×1=1245·6 ;)×2= 14·0

Function of vol. of Displ. to 3rd W. P. } 1665·7)1259·6

·755

Water-planes apart . . 3·8125

C. of Buoy. below 3rd w. plane 2·8784

4TH WATER-PLANE

Nos. of Stations	Ordinates	Cubes	Mults.	Functions
1	·2	·00	1	·00
2	5·6	175·61	4	702·44
3	10·8	1259·71	2	2519·42
4	14·3	2924·20	4	11696·80
5	16·0	4096·00	2	8192·00
6	16·5	4492·12	4	17968·48
7	16·5	4492·12	2	8984·24
8	16·5	4492·12	4	17968·48
9	16·4	4410·94	2	8821·88
10	16·1	4173·28	4	16693·12
11	14·5	3048·62	2	6097·24
12	9·3	804·35	4	3217·40
13	·2	·00	1	·00

102861·50
Longitudinal Interval . 16·6
61716900
61716900
10286150
3)1707500·900
569166·966
2
3)1138333·932

Vol. of Displ. to 3rd Water-plane } 41661·67)379444·644

Metacentre above C. of Buoy 9·108

Functions of Areas† of Water-planes { 462·0×1= 462·0×0= 0 ; 413·8×3=1241·4×1=1241·4 ; 311·4×3= 934·2×2=1868·4 ; 7·0×1= 7·0×3= 21·0

Function of vol. of Displ. to 4th W. P. } 2644·6)3130·8

1·183

Water-planes apart . . 3·8125

C. of Buoy. below 4th w. plane 4·5102

LOAD WATER-PLANE

Nos. of Stations	Ords.	Cubes	Mults.	Functs.
1	·2	·00	1	·00
2	6·8	314·43	4	1257·72
3	11·9	1685·15	2	3370·30
4	15·0	3375·00	4	13500·00
5	16·2	4251·52	2	8503·04
6	16·5	4492·12	4	17968·48
7	16·5	4492·12	2	8984·24
8	16·5	4492·12	4	17968·48
9	16·4	4410·94	2	8821·88
10	16·3	4330·74	4	17322·96
11	15·6	3796·41	2	7592·82
12	12·6	2000·37	4	8001·48
13	·2	·00	1	·00

113291·40
Longitudinal Interval 16·6
67974840
67974840
11329140
3)1880637·240
626879·080
2
3)1253758·160

Vol. of Displ. to L. W. Pl. } 62112·94)417919·386

Metac. above C of Buoy. 6·727

Functions of Areas† of Water-planes { 486·4×1= 486·4×0= 0 ; 462·0×4=1848·0×1=1848·0 ; 413·8×2= 827·6×2=1655·2 ; 311·4×4=1245·6×3=3736·8 ; 7·0×1 = 7·0×4= 28·0

Function of vol. of Displ. to L. W. P. } 4414·6 7268·0

1·646

Water-planes apart . . 3·8125

C. of Buoy. below L. w. plane 6·2714

* For sample of curve see p. 97. † For functions of areas see Displacement Paper, p. 78. ‡ Intermediate water-plane.

Preliminary Table for Stability at 30° Angle of Heel.

Nos. of Secs.	Ordinates	Multipliers	Functions of Ordinates	Squares of Ordinates	Multipliers	Functions of Squares	Cubes of Ordinates	Multipliers	Functions of Cubes
Immersed Wedge.									
1	·8	½	·4	·6	½	·3	·5	½	·3
1½	8·1	2	16·2	65·6	2	131·2	531·4	2	1062·8
2	14·2	1	14·2	201·6	1	201·6	2863·3	1	2863·3
2½	17·8	2	35·6	316·8	2	633·6	5639·7	2	11279·4
3	20·5	1½	30·7	420·2	1½	630·3	8615·1	1½	12922·7
4	20·4	4	81·6	416·2	4	1664·8	8489·7	4	33958·8
5	20·2	2	40·4	408·0	2	816·0	8242·2	2	16484·4
6	20·2	4	80·8	408·0	4	1632·0	8242·2	4	32969·6
7	20·2	2	40·4	408·0	2	816·0	8242·2	2	16484·4
8	20·2	4	80·8	408·0	4	1632·0	8242·2	4	32969·6
9	20·2	1½	30·3	408·0	1½	612·0	8242·2	1½	12363·6
9½	20·3	2	40·6	412·0	2	824·0	8363·6	2	16727·2
10	18·8	1	18·6	353·4	1	353·4	6644·7	1	6644·7
10½	15·8	2	31·6	249·6	2	499·2	3944·3	2	7888·6
11	10·6	½	5·3	112·4	½	56·2	1191·0	½	595·5
			3)547·3			3)10502·6			3)204972·9
			182·4			3500·9	Immersed	.	68324·3
							Emerged	.	58590·4
							Both wedges		126914·7
Emerged Wedge.									
1	1·1	½	·5	1·2	½	·6	1·3	½	·7
1½	6·5	2	13·0	42·2	2	84·4	274·6	2	549·2
2	10·9	1	10·9	118·8	1	118·8	1295·0	1	1295·0
2½	14·1	2	28·2	198·8	2	397·6	2803·2	2	5606·4
3	16·9	1½	25·3	285·6	1½	428·4	4826·8	1½	7240·2
4	20·0	4	80·0	400·0	4	1600·0	8000·8	4	32003·2
5	21·2	2	42·4	449·4	2	898·8	9528·1	2	19056·2
6	21·5	4	86·0	462·2	4	1848·8	9938·4	4	39753·6
7	21·2	2	42·4	449·4	2	898·8	9528·1	2	19056·2
8	20·1	4	80·4	404·0	4	1616·0	8120·6	4	32482·4
9	17·5	1½	26·2	306·2	1½	459·3	5359·4	1½	8039·1
9½	15·4	2	30·8	237·1	2	474·2	3652·3	2	7304·6
10	12·5	1	12·5	156·2	1	156·2	1953·1	1	1953·1
10½	8·9	2	17·8	79·2	2	158·4	705·0	2	1410·0
11	3·5	½	1·7	12·2	½	6·1	42·8	½	21·4
			3)508·1			3)9146·4			3)175771·3
			169·3			3048·8			58590·4

COMBINATION TABLE FOR STABILITY AT 30° ANGLE OF HEEL.

IMMERSED WEDGE

Angles of Heel	Functions of Ordinates	Functions of Squares of Ordinates	Mults.	Products
0°	—	3015·4	1	3015·4
5°	—	3098·2	4	12392·8
10°	—	3173·2	2	6346·4
15°	—	3325·4	4	13301·6
20°	—	3515·9	2	7031·8
25°	—	3773·3	4	15093·2
30°	158·4	3500·9	1	3500·9

Immersed Wedge . . .	60682·1
Emerged Wedge . . .	54148·8
	2) 6533·3
	3266·7
⅓ Angular Interval . .	·0291
	32667
	294003
	65334
	95·06097
Longitudinal Interval . .	20
Excess of Immersed Wedge	1901·22
Appendage	396·00
Area of Water-plane . 7197)	2297·22
Thickness of Layer . .	·32

EMERGED WEDGE

Functions of Ordinates	Functions of Squares of Ordinates	Multipliers	Products
—	3015·4	1	3015·4
—	2976·3	4	11905·2
—	2974·1	2	5948·2
—	2991·3	4	11965·2
—	3031·0	2	6062·0
—	3051·0	4	12204·0
169·3	3048·8	1	3048·8
			54148·8

INCLINED WATER-PLANE

Functions of ordinates {Immersed side	158·4
{Emerged side .	169·3
	327·7
Longitudinal Interval . .	20
Uncorrected Area . . .	7034
Appendage	163
Total Area	7197
Functions of squares {Immersed side .	3500·9
{Emerged side .	3048·8
	2) 452·1
	226·05
Longitudinal Interval . .	20
Uncorrected Moment . .	4521
Moment for Appendage .	3018
Area of Water-plane . 7197)	8339
C. of G. towards immersed side	1·16

BOTH WEDGES

Statical Stability

Sums of Functions of Cubes	Multipliers	Products	Cosines of Heel	Products for Moments
111478·2	1	111478·2	·8660	96540·1
112940·9	4	451763·6	·9063	409433·4
115141·4	2	230282·8	·9397	216396·7
120230·2	4	480920·8	·9659	464521·4
127258·5	2	254517·0	·9848	250648·3
135665·3	4	542661·2	·9962	541515·6
126914·7	1	126914·7	1·0000	126914·7

	3)2105970·0
	701990·0
⅓ Angular Interval .	·0291
	7019900
	63179100
	14039800
	20427·90900
Longitudinal Interval . . .	20
Moment of Wedges uncorrected .	408558·18
Correction for appendages . . .	8839·00
„ „ layer . . .	−2354·00
Volume of Displacement . 86767)	415044·18
BR=	4·78
BG . sine 30°=	3·13
GZ=Statical Lever=	1·65

Dynamical Stability

Sines of Heel	Products for Moments
·5000	55739·1
·4226	190908·9
·3420	78756·7
·2588	124463·3
·1736	44184·2
·0871	47345·9
·0000	·0

	3)541398·0
	180464·0
⅓ Angular Int.	·0291
	1804640
	16241760
	3609280
	5251·50240
Long. Int.	20
	105030·048
	1547·009
	−367·009
	86767)106210·048
B_1R= .	1·224
BG . vers 30°=	·839
Dynam. Lever=	·385

Moment of Statical Stability in foot tons =3479×1·65=4090

Moment of Dynamical Stability in foot tons =3479×·385=954

APPENDAGES

Pieces	Area	Mo. of Area	Vols.	Mo. of Vols.
Battery	150	3496	650	14381
Stern Im.	39	130	69	279
Stern Em.	12	−12	−12	−36
Negative	−37·5	−603·7	−309	−5700
Totals	163·5	3018·3	398	8839

CORRECTING LAYER

Moment for Statical Layer

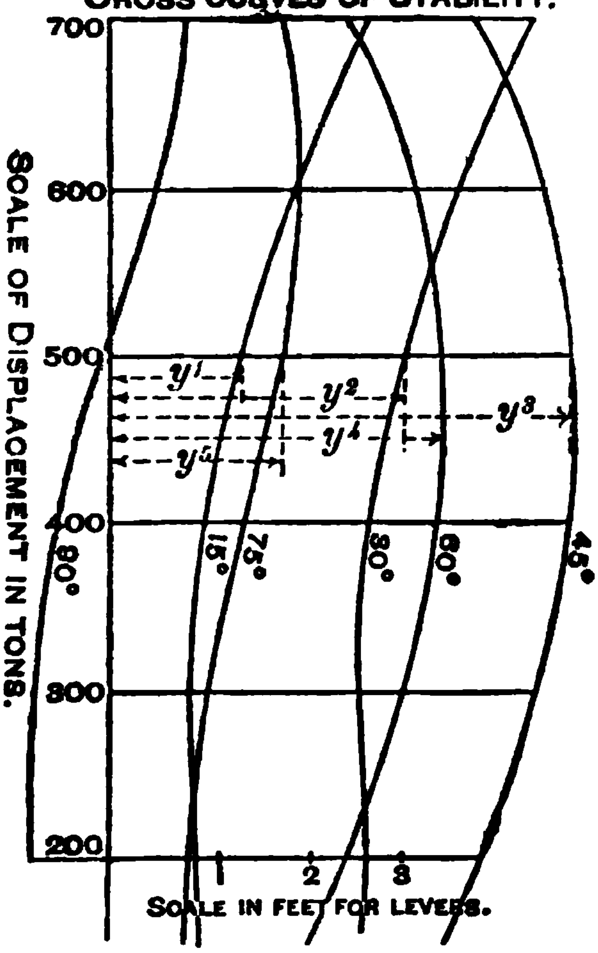
Longitudinal Int.=20 feet. Angular Int.=5 deg. C. of Grav. above C. of Buoy.=6·26. Vol. of Displacement=86767. Displacement in tons=3479.

CROSS CURVES OF STABILITY.

These curves may be termed 'vertical curves of stability,' and defined as the locus of the arms of the righting moments at various draughts or displacements at certain fixed angles of heel. They hold a somewhat similar relation to the ordinary curves of stability as the body plan of a ship does to its water plane.

FIG. 156.

CROSS CURVES OF STABILITY.

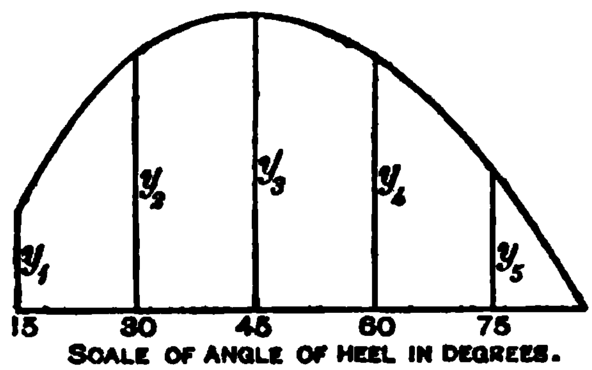


For cross curves (see fig. 156) the righting levers are calculated at certain fixed degrees of heel at various draughts or displacements, and the levers are set up as ordinates from an axis the abscissæ of which represent the displacements at which the levers for the fixed degree of heel are found.

A number of such curves are constructed for various inclinations, and set off as in fig. 156.

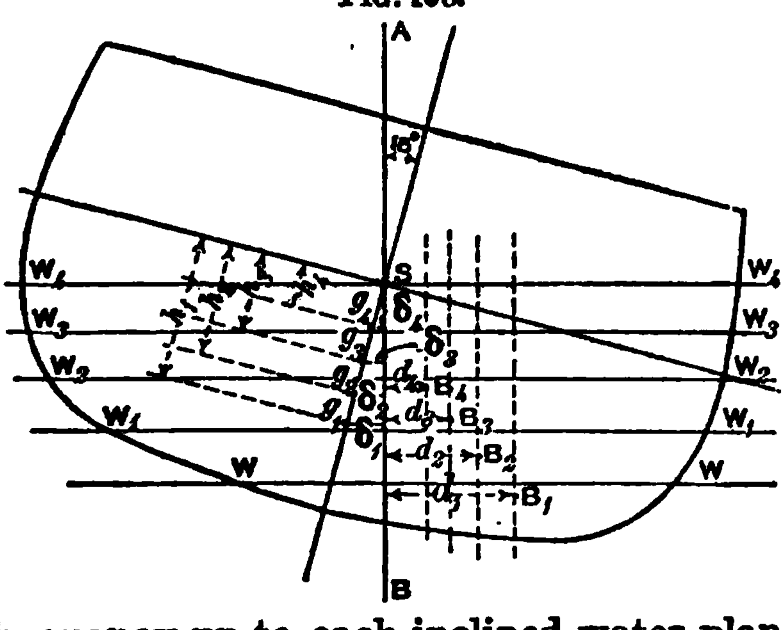
FIG. 157.

CURVE OF STABILITY AT 500 TNS. DISPLACEMENT.



For finding such curves at various draughts and angles of heel, say at 15° (see fig. 158), divide the body plan by a number of parallel planes representing various draughts of water or displacements.

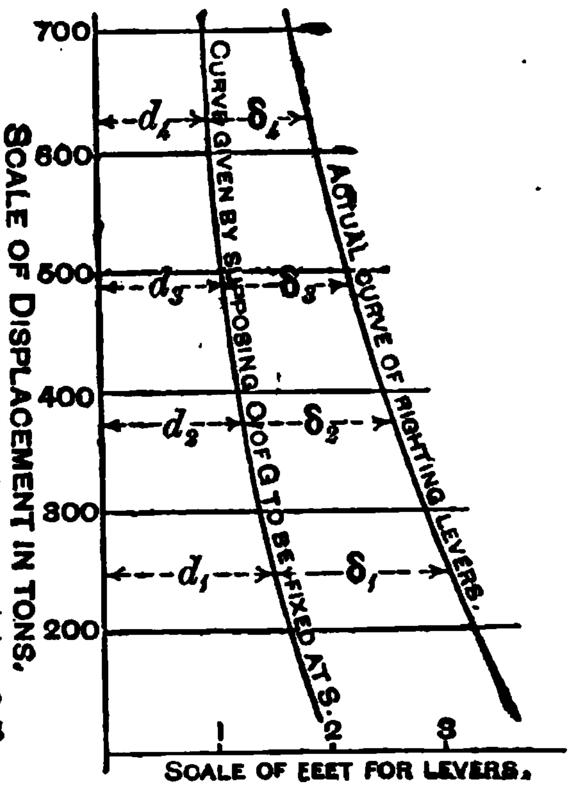
FIG. 158.



Drop a perpendicular through the point where the highest water line cuts the middle line of the ship, and then calculate the horizontal distances d_1, d_2, d_3, &c., of the centre of buoyancy up to each inclined water-plane from the vertical AB.

By assuming the centre of gravity to be at S, and fixed there for all draughts, the distances d_1, d_2, d_3, &c., would be the righting levers at the displacements, up to the respective water planes W_1, W_2, W_3, W_4.

FIG. 159.



These lengths are then set off as ordinates along an axis having the several displacements up to the water planes as abscissæ.

The actual righting levers can then be determined, when the correct positions of the centres of gravity corresponding to the various displacements are fixed, by multiplying the respective distances h_1, h_2, h_3, &c., of the actual centres of gravity g_1, g_2, g_3, g_4 below S by the sine of the angle of heel, and adding this length to the arms already found (see fig. 159).

The actual righting lever for the displacement up to W_4, W_4 would be equal to $d_4 + h_4 \sin 15° = d_4 + \delta_4$.

Up to W_3, W_3 it would be equal to $d_3 + h_3 \sin 15° = d_3 + \delta_3$, &c.

Should any of the centres of gravity be above the point S, a deduction would have to be made equal to the distance h of the centre of gravity above S multiplied by the sine of the angle of heel.

The horizontal distances of the centres of buoyancy d_1, d_2, &c., are equal to the moment of displacement, up to the various water planes, divided by their respective volumes. The rules given on p. 79 will show how this can be done. By using Amsler's integrator the time necessary for the above calculation can be considerably shortened, as the volumes of displacements and the moments of same can be found by its means in one operation.

Note in fig. 158 the various vertical sections of the body are left out to make the diagram more clear.

APPROXIMATE METHOD OF DETERMINING STABILITY DUE TO ADDING WEIGHT. (FIG. 160.)

Before adding a weight

Let W L = load water-line.

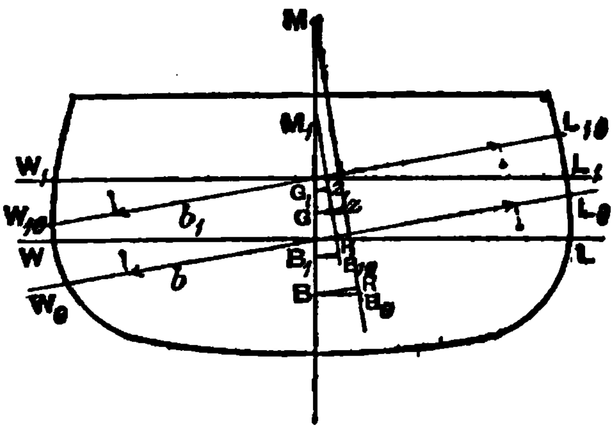
G = centre of gravity.

B = centre of buoyancy for upright position.

B^{θ} = centre of buoyancy for angle θ.

M = metacentre.
G Z = righting arm at angle θ, and
B R and G Z perpendicular to B_θ M and parallel to $W_\theta L_\theta$.
V = volume of either wedge at angle θ.

FIG. 160.



b = Distance between centres of wedges on inclined water-line.

Stability at original draught
$= W . GZ = W . GM \sin \theta$
$= W (BM - BG) \sin \theta$
$= W . BM \sin \theta - W . BG \sin \theta$,
and $W . BM \sin \theta = W . BR = b . V$.
∴ Stability at $W_\theta L_\theta$
$= W . BG \sin \theta$.

Then when a weight w is added let WL, G, B, &c., become W_1, L_1, G_1, B_1, &c.

Also let d = height of centre of w above B,
c = height of centre of additional displacement above B.

The stability is then represented by

$$(W + w)\, G_1Z_1 = (W + w)\, G_1M_1 \sin \theta$$
$$= (W + w)\, (B_1M_1 - B_1G_1) \sin \theta$$
$$= (W + w)\, (B_1\, M_1 \sin \theta) - (W_1 + w)\, (B_1G_1 \sin \theta) \;.\;.\; (1);$$

but $(W + w)\, B_1\, M_1 \sin \theta = (W + w)\, B_1\, R_1 = b_1\, V_1$,
and $B_1\, G_1 = BG + GG_1 - BB_1$;

$\therefore\; (W + w)\, B_1\, G_1 = W . BG + w\, BG + (W + w)\, GG_1 - (W + w)\, BB_1$;
but $w . BG + (W + w)\, GG_1$ = moment of weight w about original centre of buoyancy $B = wd$.

Also $(W + w)\, BB_1$ = moment of additional displacement about original centre of buoyancy $B = w . c$.

Substituting these quantities in equation (1), the stability corresponding to the water-line $W_{1\theta}L_{1\theta}$
$= b_1V_1 - W . BG \sin \theta - w\, (d - c) \sin \theta$ . . . . (2)
The stability corresponding to $W_\theta\, L_\theta = b\, V - W . BG \sin \theta$ . . . (3)

Subtracting (3) from (2) the difference of stability under the above conditions $= b_1V_1 - bV - w\, (d - c) \sin \theta$ . . . . (4)

If the new water-line is nearly the same as the original, the volumes of the wedges corresponding to the respective draughts will be nearly the same, so that in equation (4) $b_1\, V_1$ is practically equal to $b\, V$, and the difference in stability at the two draughts of water becomes $= -w\, (d - c) \sin \theta$, and if $d = c$ the stability at the two draughts will be the same.

If d be greater than c the stability will be diminished by the quantity $w\, (d - c) \sin \theta$.

If d is less than c the stability is increased by the quantity $w(c - d) \sin \theta$.

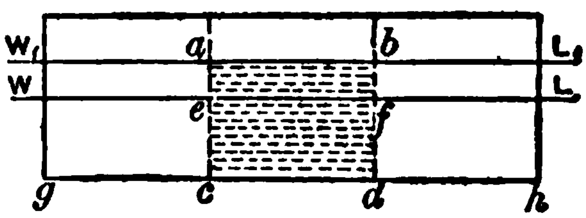
Initial Statical Stability as affected by admitting Water into Watertight Compartments.

The compartments are supposed to be empty. The volume of frames, plating, &c., is neglected; and the alteration in trim is neglected.

1st case. (Fig. 161.)

Water admitted to a compartment between transverse bulkheads, so that the water-line in the compartment is coincident with the water-line outside.

Fig. 161.



WL = original water-line.

$W_1 L_1$ = new water-line.

$a\,b\,c\,d$ = compartment with water admitted.

$e\,f\,d\,c$ = volume of water in compartment below original water-line.

Displacement remains constant

$$\text{volume } (W_1\,a\,e\,W + L_1\,b\,f\,L) = \text{volume } e\,f\,d\,c.$$

Neglect the compartment $a\,b\,c\,d$, as it does not form part of the vessel, take the two ends of the ship, $W_1\,a\,c\,g$ and $L_1\,b\,d\,h$; join them together as a new vessel, and determine the height of the metacentre above the centre of buoyancy in the ordinary way.

2nd case. (Fig. 162.)

Water admitted to a watertight compartment bounded by transverse bulkheads and a watertight flat.

a. If the compartment is entirely filled with water the effect is the same as that of added weight, altering both centre of gravity and centre of buoyancy.

If the centre of gravity of the added water be above that of the added displacement, the stability will be diminished; if below, the stability will be increased.

b. If the compartment is below the water-line and not entirely filled with water.

Let M (fig. 162) = metacentre with free water on board.

θ = angle of inclination.

B and B′ = centres of buoyancy when upright and inclined respectively.

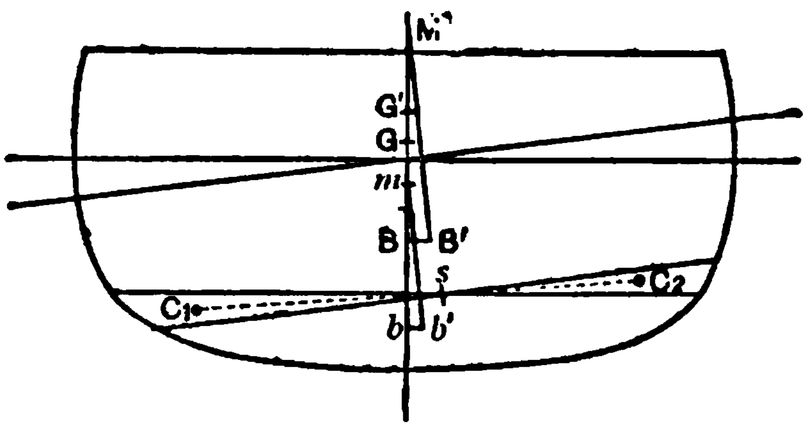
b and b' = centres of gravity of free water when upright and inclined respectively.

G = centre of gravity of ship and free water when upright.

S = intersection of upright and inclined free-water surfaces.
W = weight of ship and free water in tons.
V = volume of displacement in cubic feet.
v = volume of free water only in cubic feet.
i = moment of inertia of free water-surface about fore and aft axis through S.

The ship, as she inclines through the angle θ, has the centre of buoyancy B carried to B′, and the centre of gravity of the free

FIG. 162.



water carried from b to b'. If C_1 and C_2 be the centres of gravity of the wedges of emersion and immersion respectively of the free water, and v_θ be the volume of either wedge, then

$$C_1C_2 \times v_\theta = bb' \times V.$$

It is evident that $C_1C_2 \times v_\theta = i \times \sin\theta$.

Then $bb' \times V = i \times \sin\theta$, or $bm = \dfrac{bb'}{\sin\theta} = \dfrac{i}{V}$, where m is the intersection of the verticals through b and b'.

Then for any small angle of inclination, the water in the ship will shift round until its centre of gravity is in a vertical line with m, so that for heeling purposes its centre of gravity may be considered to be at m instead of b.

This will raise G, the centre of gravity of the ship and water, to G′, so that $GG' \times W = bm \times 35 \times v$.

Then $$GG' = \frac{bm \times 35v}{W} = \frac{bm \times v}{V} = \frac{i}{v} \times \frac{v}{V} = \frac{i}{V}.$$

So that the loss of metacentric height, due to the mobility of the water, is equal to the moment of inertia of its free surface divided by the total volume of displacement.

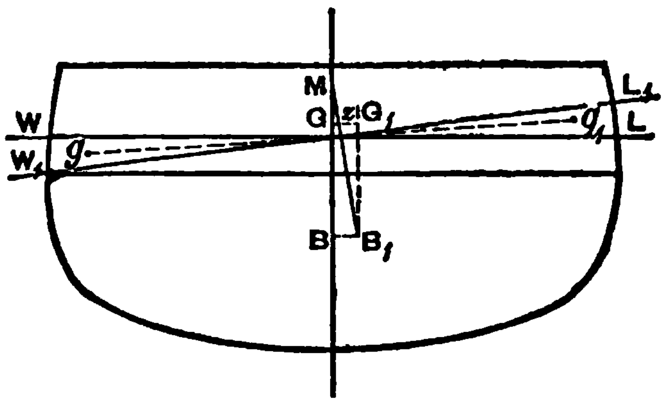
The moment of stability for a small angle θ

$$= W \times G'M \times \sin\theta = W \times (GM - GG') \times \sin\theta = W \times \left(GM - \frac{i}{V}\right) \sin\theta.$$

3rd case.

When water is let on to a watertight flat at or about the water-line, so that the water-line outside is coincident with the water-line inside (see fig. 163).

FIG. 163.



When the ship is inclined, the centre of buoyancy B moves to B_1 parallel to g, g_1; and because the wedge of water moved inside is similar and equal to the one outside, G has also moved to G_1 in a line parallel and equal to BB_1.

Join B_1 to the metacentre M; then if W = displacement of ship, and θ angle of inclination,

$$W \,.\, G_1Z = \text{moment of upsetting couple,}$$
$$\text{and is } = W \,.\, BG \,.\, \sin\theta.$$

The maximum upsetting force is when the water-line inside meets the watertight flat; the upsetting force will then commence to diminish.

In the above case, if G were coincident with B, her stability would be neutral; if below, she would be stable.

If the moment of inertia, about a longitudinal axis passing through the centre of gravity, of the surface of water on any deck were greater than the moment of inertia of the water-line, the upright position would be one of instability provided G were above B.

MECHANICAL METHOD OF MEASURING A VESSEL'S STABILITY. (J. H. HECK, M.I.N.A.)

(From *Transactions of Institution of Naval Architects*, 1885.)

Description of Stability Balance (figs. 164–167):

A. Two mahogany levers rigidly attached to each other, and fixed to a steel bar, B, working upon plates C, C, as a fulcrum.

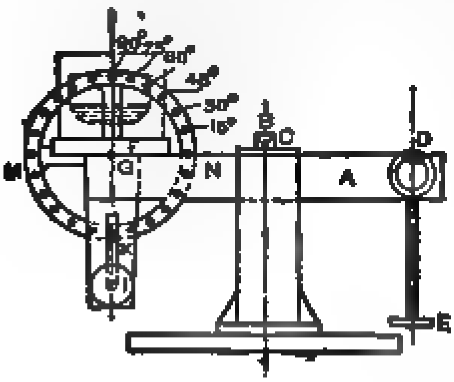
D. Steel bar fixed at end of levers, A, A, carrying 2 scale-pans, E, E, on knife edges.

F. Mahogany table attached to spindle, G, which works in

bearings; this table can be turned round and kept at any angle of 15° interval by means of the wheel M and pin N.

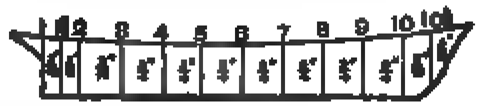
K. Frame attached to underside of table F, having a slot cut out as shown, in which the balance-weight I works.

FIG. 164.



To make an Inside Sectional Model. — Suppose the longitudinal plan to be divided as shown, and let the thickness of middle section be $\frac{3}{4}''$; then thickness of end sections will be as in fig. 165.

FIG. 165.



Cut the boards out to the various sections and bolt them together, with their middle lines in one plane, as in fig. 166.

FIG. 166.

Suitable fittings are provided for pouring in and drawing off the water, a glass plate being let in one end to show the height of water in the model; the various sections are varnished before being bolted together.

Method of using Balance.—Secure the model to platform F, and place weight in one scale-pan until the model balances.

Incline model through 90 and adjust balance-weight I so that the model still balances the weight in scale-pan.

Now turn the model through the successive angles 15°, 30°, &c., tabulating the weights required in the scale-pan to balance model at each inclination.

Bring model back to horizontal position; put weight in No. 1 scale-pan to balance it; now pour water in until it reaches the water-line marked inside, as seen through the glass end. Put weights in No. 2 scale-pan until model again balances; this is equal to the weight of water in model = D.

Now turn model to desired angle. Put the weight previously found necessary to balance the model at that angle into No. 1 scale-pan. Add or subtract weight to No. 2 scale-pan until model balances; the actual weight then in No. 2 scale-pan is that necessary to balance the water when inclined at that angle. Let this weight = W.

Then, by the principle of the lever,

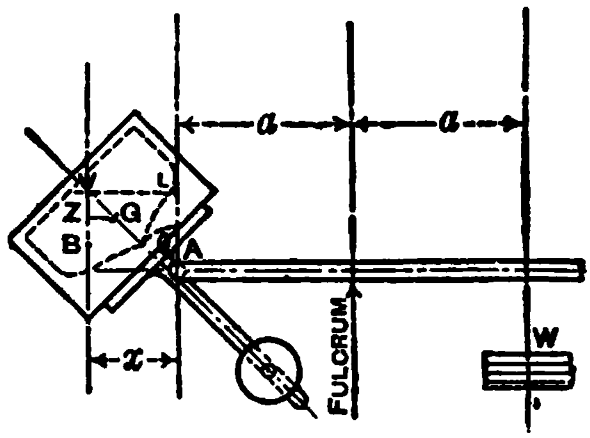
$$W \cdot a = D\,(x + a).$$

$$\therefore\ x = \frac{Wa}{D} - a.$$

Now, if G is the centre of gravity of the vessel, GZ is the righting lever $= (x - \text{GA} \sin \theta)$.

$$\therefore\ \text{GZ} = \left(\frac{Wa}{D} - a - \text{GA} \sin \theta\right).$$

FIG. 167.



To check this result the model may be inclined the reverse way; then if W_1 is the weight required to balance model,

$$x = a - \frac{W_1 a}{D};$$

from which x may be found and the mean value of the two results taken as correct.

Note.—This method may be modified by using a tank containing water and a solid model partly immersed in the tank.

APPROXIMATE METHOD OF FINDING A VESSEL'S STABILITY. (BY S. W. BARNABY, ESQ.)

(From a Letter in the *Marine Engineer* for 1883.)

Prick off on a sheet of drawing-paper from the body plan of the ship any convenient number of immersed sections taken at equal intervals apart. Cut these sections out with a pair of scissors and gum them together in their relative positions; care must be taken to spread the gum thinly and evenly. The weight of these sections represents the displacement of the ship. By suspending this collection from two different points, and taking the intersection of two vertical lines through these points, the position of the centre of buoyancy is obtained. Draw on the body plan a number of water-lines at various angles of heel, all the lines intersecting at the centre of the upright water plane.

Cut out as before the immersed sections corresponding to the first inclined water-line, and gum them together.

The actual floating line at this angle of heel may be obtained by cutting off parallel slices from the top of the sections until the weight is the same as those in the upright position. Find the centre of buoyancy as before, by suspending them from two points.

The distance between the vertical line drawn through the new position of the centre of buoyancy thus found and a vertical

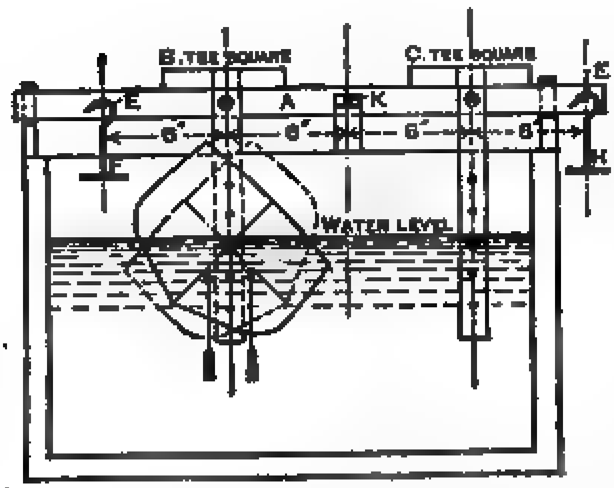
line through the centre of gravity of the ship is the arm of the righting couple.

If this process is repeated for each angle a complete curve may be obtained.

Mechanical Method of Measuring a Vessel's Stability. (By J. H. Heck.)

(From *Transactions of Institution of Naval Architects*, 1887.)

Fig. 168.



A, steel straight-edge.

B and C, steel tee-squares fastened to straight-edge by a small bolt.

E, E, knife edge bars at ends of straight-edge, from which the scale-pans F and H are suspended.

K, knife edge bar on which the straight-edge oscillates.

A small sensitive spirit-level having a ground glass is fixed to the straight-edge in order to ascertain when it is balanced.

To make a model, procure some sheets of oil-paper such as is used in a letter copying-press, and with spirit varnish join four sheets together. After this, mark on each piece a vertical line *xx*, and two horizontal lines *yy*, the lower line *yy* being in the position of the assumed centre of gravity of vessel, about 3 ins. apart, at their intersections; cut out with a chisel $\frac{5}{16}$ in. square holes, so that the sheets will slip over the pins P, P (see fig. 169).

Fig. 169.

Divide the length of the ship into about 12 equal intervals, and then from the body plan make a tracing of the form of the vessel at the centre of each interval. Mark on the tracing the assumed position of the centre of gravity of the vessel and draw an horizontal line through it.

Prick off each of these sections on to the prepared paper, keeping the centre of gravity well with the lower line marked *yy*.

Lay the first section on a board having two pins P, P on it to keep the section in place; varnish this section and place the next

one over it; repeat the process until all the sections are stuck together. When dry remove the model and varnish it; the various angles for which righting arms are required are then marked on the model.

The model is then fastened to the tee-square B by a small bolt.

The tee-square C being exactly the same as the tee-square B, and being at equal distances from the fulcrum, they will neutralise one another when immersed in the water or otherwise.

To determine the righting lever at any angle or displacement, fix the model to the tee-square B, and turn it to the desired angle, pivoting it about the centre of gravity.

Find the weight necessary to be put in the scale-pan H, in order to balance model.

Find the same when the tee-square is turned halfway round, so that the model comes into the position shown by the dotted lines in fig. 168.

Pour water into the tank until the model is immersed to any desired depth; put into the scale-pan H the weight necessary to balance the model, and into the scale-pan F weight to balance the upward pressure of the water; let this latter be called W then.

W multiplied by its distance from the fulcrum = water displaced by model multiplied by its distance from the fulcrum.

To find the displacement, turn the tee-square halfway round, back to its original position, put into the scale-pan H the weight necessary to balance the model, and into the scale-pan F weight to balance the upward pressure of the water; let this be called W_1; then water displaced by model $= W_1 + W$; consequently, the righting-lever and displacement are determined, as the distance of the centre of gravity of the vessel from the fulcrum is a constant known quantity.

The displacement of the vessel corresponding to each ounce of water displaced by the model can be found by the balance; by finding the water displaced by the model at the upright position, when immersed to the load draught, for—Displacement of actual vessel at load draught ÷ by weight of water in ounces displaced by model, equals tons of displacement to each ounce of water displaced by model.

Approximate formulæ for the calculation of Trim (J. A. Normand, M.I.N.A.)

Let L = length of LWL in feet.
l = breadth amidships in feet.
D = displacement in cubic feet.
A = area of LWL in square feet.
H = height of longitudinal metacentre above centre of buoyancy.

We may write $H = \phi\left(\frac{A}{L\,l}\right)\frac{L^3 l}{D}$;

that is to say, when the ratio of the area of L W L to the circumscribing parallelogram remains constant, H varies as $\frac{L^3 l}{D}$.

Now the value of $\phi\left(\frac{A}{L\,l}\right)$ is very nearly $= \cdot 008 + \cdot 077\left(\frac{A}{L\,l}\right)^3$,

$$\text{so that } H = \left\{\cdot 008 + \cdot 077\left(\frac{A}{L\,l}\right)^3\right\}\frac{L^3 l}{D}.$$

For values of $\frac{A}{L\,l}$ ranging between ·68 and ·81, that is to say, in most cases, the function $\phi\left(\frac{A}{L\,l}\right)$ may be taken as $\cdot 0735\left(\frac{A}{L\,l}\right)^2$, so that the approximate value of H becomes

$$H = \cdot 0735\frac{A^2 L}{l\,D}.$$

Now the alteration of trim x in inches, due to shifting a weight P in tons through a distance d in feet, is

$$x = 35 \times 12\frac{P d L}{H_G D},$$

H_G denoting the height of the longitudinal metacentre above the centre of gravity of the ship, which may be taken as $= \frac{H}{1 \cdot 015}$,

$$\text{then } x = \frac{35 \times 12 \times 1 \cdot 015}{\cdot 0735} \times \frac{P \times d \times l}{A^2},$$

$$\text{or } x = 5800\frac{P d l}{A^2},$$

and the moment in foot tons to alter trim one inch

$$= P d = \cdot 0001725\frac{A^2}{l}.$$

When the weight P, instead of being shifted, is put on board, at a distance d from the centre of gravity of W L, we get Immersion of end where weight is put on board

$$= 420\frac{P}{A}\left(1 + 6 \cdot 91\frac{l d}{A}\right).$$

Immersion of end opposite to that where weight is put on board

$$= 420\frac{P}{A}\left(1 - 6 \cdot 91\frac{l d}{A}\right).$$

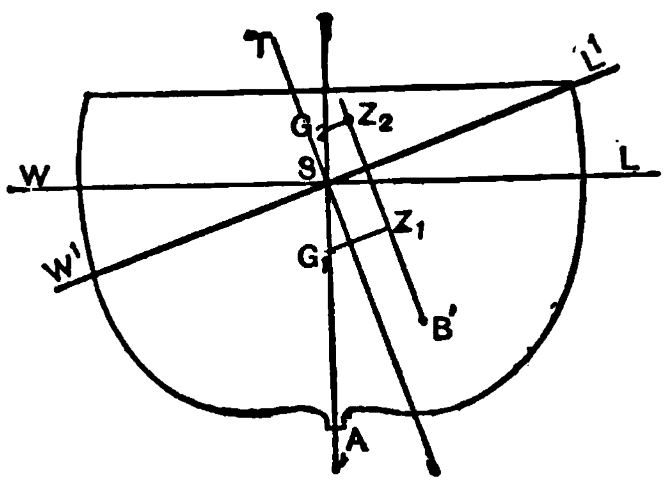
In the above formulæ the rotation is assumed to take place round the middle, instead of the centre, of gravity of the L W L.

AMSLER-LAFFON'S MECHANICAL INTEGRATOR.

By means of this instrument, the area, moment, and moment of inertia about any axis, can be obtained for any curvilinear area by tracing its outline with a pointer.

Its principal use is that of obtaining the stability of a vessel at various angles of heel and at various drafts. It is usual, when using this instrument, to first calculate the righting lever for a number of displacements at *one* inclination, say 15°. Then the same for 30°, 45°, and so on; the cross curves being constructed before the ordinary curves.

FIG. 170.



Let fig. 170 be a body plan drawn for both sides of a ship; let WL be its upright waterline intersecting the middle line at S. Through S draw inclined waterlines at the required inclinations, and let W′L′ be any one of them, say at 15°. The first step is to find the displacement at W′ L′ as it is generally different from that at WL. The pointer is passed (i) round the two end sections, (ii) round the dividing sections, and (iii) round the intermediate sections* ; the pointer in each case passing along the waterline and round the section, as W′L′AW′. Readings are taken at the start and after passing round (i), (ii), and (iii), so that after subtracting, the readings due to each of the three series of sections are known. Reading (ii) is multiplied by 2, and (iii) by 4, and the two products added to reading (i). The total is then multiplied by the common interval and the constant of the instrument and divided by 3 times the square of the scale used. The result is the volume of displacement, which is then reduced to tons.

If in the same way ST, the line through S, perpendicular to W′L′ is made the axis for moments, and the readings for moments are treated in the same way as those for areas, it is evident that the final result will be the moment of the underwater portion about ST as axis (obviously, the total must now be divided by 3 times the *cube* of the scale instead of the square). This divided by the volume of displacement will give the perpendicular distance of the inclined centre of buoyancy from ST; that is SZ, when B′Z is parallel to ST.

The righting lever, or GZ, is equal to SZ + SG sin θ when G is below S as at G_1; and equal to SZ − SG sin θ when G is above S.

The righting lever GZ is set off at its proper displacement on the cross curve for 15°. This is done at different waterlines and the cross curve thus completed.

* See Simpson's Rules.

The following is the actual form of the calculation for SZ.

Sections 10·6 apart. Scale of body ¼″ to 1 foot.

$$\text{Machine constants}\begin{cases}\text{Areas} & \dfrac{20}{1000}.\\[2ex] \text{Moments} & \dfrac{40}{1000}.\end{cases}$$

ANGLE OF HEEL 15°								
--	Areas				Moments			
Sections	Readings	Differences	Simpson's Multipliers	Products	Readings	Differences	Simpson's Multipliers	Products
Initial . .	4029	—	—	—	982	—	—	—
End ordinates .	4111	82	1	82	986	4	1	4
Dividing ordinat.	10502	6391	2	12782	1398	412	2	824
Intermediate „ .	17309	6807	4	27228	1819	421	4	1684
				40092				2512

Displacement in tons

$$=40092\times\frac{20}{1000}\times(4)^2\times\frac{10\cdot5}{3}\times\frac{1}{35}=1283.$$

$$\text{SZ}=\frac{2512}{40092}\times\frac{40}{20}\times4=\cdot5\text{ feet.*}$$

Tchebycheff's rule (see p. 43) can be employed instead of Simpson's rule in the above. In that case 9 ordinates on Tchebycheff's plan would be sufficient; the pointer being passed round all the sections, and the initial and final readings taken.

Example.—Length of ship, 210 feet; number of sections, 9; scale of body, ¼″ to 1 foot.

$$\text{Displacement in tons}=\frac{20}{1000}\times16\times\frac{210}{9}\times\frac{1}{35}\times\text{area reading.}$$

$$\text{SZ}=\frac{\text{Moment reading}}{\text{Area reading}}\times8\left(\begin{array}{l}4=\text{the scale}\\2=\text{ratio of}\\\text{machine con-}\\\text{stants.}\end{array}\right)$$

* The 4 multiplier is the reciprocal of the scale of the drawing.

WAVES.

SEA WAVES.

In the ordinary sea wave, or wave of oscillation, the form alone has a translatory motion, as the particles composing it revolve at a uniform rate in circular orbits, the radius of these orbits varying with the undisturbed depth, but remaining constant for particles in any subsurface or subsurface of equal pressure horizontal when undisturbed; the form of wave-surface thus formed being trochoidal (see fig. 171), as also the form of any subsurface (see fig. 172), the only difference being that while the diameter of the rolling circle of the subsurface remains the same as for the wave-surface, the length of its tracing arm diminishes in geometrical progression in going downwards.

Note.—For easy method of constructing trochoid see fig. 176, p. 131.

FIG. 171.

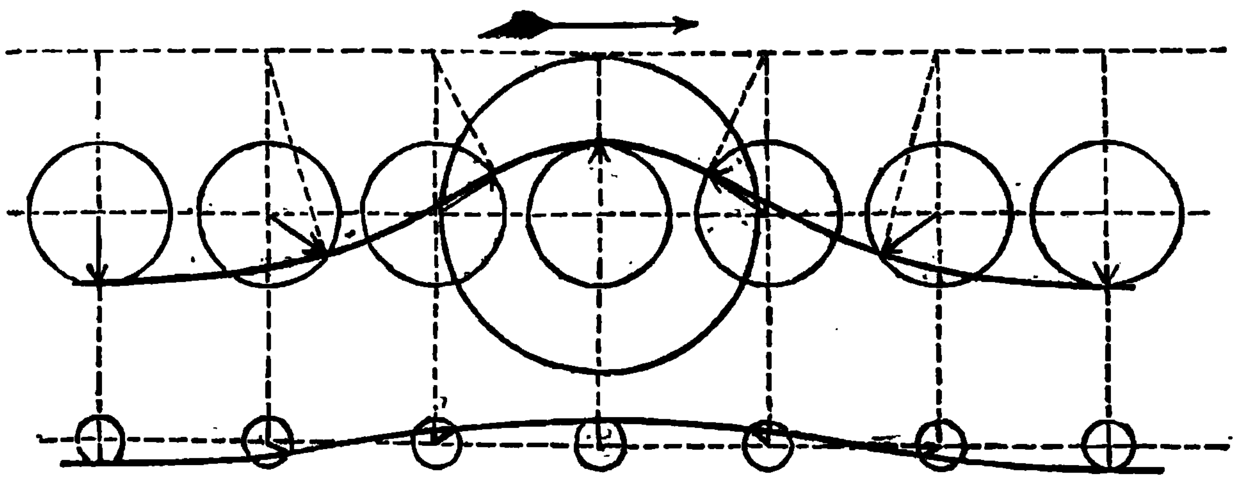
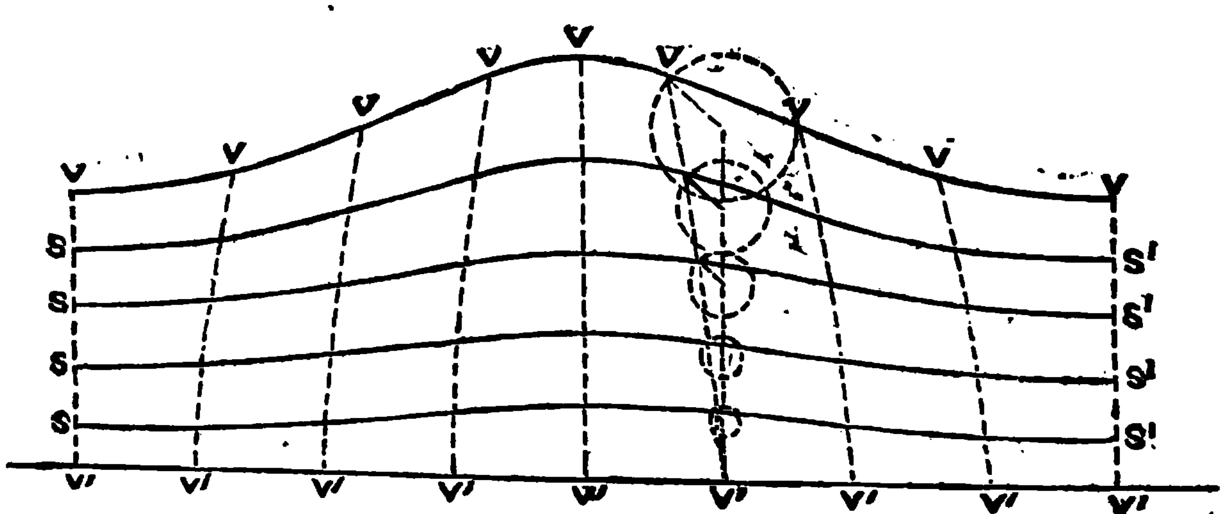


FIG. 172.



V, V' are columns of water which are vertical in still water.
S, S' are subsurfaces of equal pressure horizontal in still water.

FORMULÆ.

T = periodic time of wave in seconds.
L = length of wave in feet.
V = velocity of advance of wave in feet per second.

V_1 = velocity of advance of wave in knots per hour.
V_2 = velocity of advance of wave in miles per hour.
R = radius of rolling circle in feet.
r = radius of tracing arm for wave-surface in feet.
g = accelerating force of gravity = 32·2 nearly.
v = linear velocity of wave-surface particle in its orbit.
s = sine of steepest slope of wave-surface.
h = height of wave in feet.

$$T = 2\pi\sqrt{\frac{R}{g}} = \frac{2\pi r}{v} = \frac{L}{V} \qquad R = \frac{T^2 g}{4\pi^2} = \cdot 8154T^2 = \frac{L}{2\pi}$$

$$V = \sqrt{gR} = \frac{gT}{2\pi} = \sqrt{\frac{Lg}{2\pi}} = \frac{L}{T} \qquad V_1 = \frac{V}{1\cdot 688} = V \times \cdot 5924$$

$$V_2 = \cdot 6817V = 1\cdot 151V_1 \qquad L = 2\pi R = \frac{2\pi V^2}{g} = \frac{V^2}{5\cdot 1233} = V \times T$$

$$v = \frac{2\pi r}{T} = r\sqrt{\frac{g}{R}} \qquad s = \frac{h}{2R} = \frac{h\pi}{L}.$$

RULES. (*Rankine.*)

1. *To find the ratio in which the orbits and velocities of the particles are diminished at a given depth below the wave-surface.*

RULE.—Divide the given depth by the equivalent pendulum which is equal to the radius of the rolling circle; the natural number answering to the quotient in a table of hyperbolic logarithms will be the reciprocal of the ratio required.

Note.—Approximately the orbits and velocities of the particles of water are diminished by *one-half* for each additional depth below the surface, equal to *one-ninth of a wave-length.*

Example $\begin{cases} \text{Depth in fractions of a wave-length } 0\ \frac{1}{9}\ \frac{2}{9}\ \frac{3}{9}\ \frac{4}{9}, \text{ \&c.} \\ \text{Proportionate velocities and diameters } 1\ \frac{1}{2}\ \frac{1}{4}\ \frac{1}{8}\ \frac{1}{16}, \text{ \&c.} \end{cases}$

2. *To find how high the centre of the orbit of a given particle is above the level of that particle in still water.*

RULE (*a*).—Divide the square of the diameter of the orbit by eight times the equivalent pendulum of the waves.

RULE (*b*).—Divide the square of the velocity of the particle in feet per second by 64·4 for the height in feet.

3. *To find the mechanical energy of a layer of water agitated by wave-motion.*

RULE.—Multiply the weight of the layer by twice the height at which the centres of the orbits of the particles stand above the positions of those particles when in still water.

Note.—One half of this energy consists in motion and the other half in elevation.

4. *To find the mechanical energy of a mass of water of a given horizontal area and of unlimited depth agitated by waves.*

RULE.—Multiply the area by one-sixteenth part of the square of the height of the waves and by the heaviness of the fluid (64 lbs. per cubic foot for sea water).

5. *To find the energy of one wave-length of a layer of water of a given breadth and thickness.*

RULE.—Multiply together the breadth and thickness of the layer, the square of the diameter of the orbits of the particles in it, the heaviness of the fluid and the constant $\frac{\pi}{2} = 1{\cdot}5708$.

TABLE OF THE PERIODS AND LENGTHS OF SEA WAVES.

Velocity in Knots per Hour	Velocity in Feet per Second	Velocity in Statute Miles per Hour	Period in Seconds	Equivalent Pendulum in Feet	Length in Feet
1	1·688	1·15	·33	·09	·56
2	3·376	2·30	·66	·36	2·25
3	5·064	3·45	·98	·80	5·06
4	6·752	4·60	1·31	1·43	9·00
5	8·44	5·75	1·64	2·24	14·05
6	10·13	6·91	1·97	3·22	20·2
7	11·82	8·06	2·30	4·38	27·5
8	13·50	9·21	2·63	5·72	36·0
9	15·19	10·36	2·96	7·24	45·5
10	16·88	11·51	3·29	8·94	56·2
11	18·57	12·66	3·32	10·8	68·0
12	20·26	13·81	3·65	12·9	80·9
13	21·94	14·96	4·27	15·1	95·0
14	23·63	16·11	4·60	17·5	110·1
15	25·32	17·26	4·93	20·1	126·4
16	27·01	18·42	5·26	22·9	143·8
17	28·70	19·57	5·59	25·8	162·3
18	30·38	20·72	5·92	29·0	182·0
19	32·07	21·87	6·25	32·3	202·8
20	33·76	23·02	6·58	35·8	224·7
21	35·45	24·17	6·91	39·4	247·8
22	37·14	25·32	7·24	43·3	272·0
23	38·82	26·47	7·57	47·3	297·3
24	40·51	27·62	7·90	51·5	323·6
25	42·20	28·77	8·23	55·9	351·2
26	43·89	29·93	8·56	60·4	379·8
27	45·58	31·08	8·89	65·2	409·6
28	47·26	32·23	9·21	70·1	440·5
29	48·95	33·38	9·54	75·2	472·5
30	50·64	34·53	9·87	80·5	505·7

SHALLOW-WATER WAVES.

In shallow water of uniform depth the orbit of each particle is an oval, the orbits becoming more flattened the nearer the particles are to the bottom.

As an approximation water may be taken as *shallow* when the depth is between $\frac{5}{12}$ and $\frac{1}{36}$ of a wave-length.

l = length of shallow-water wave in feet.
L = length of l computed as if for deep water.
v = velocity of advance of shallow-water wave in feet per sec.
V = velocity of advance of wave computed as if for deep water.
d = depth of water = height of orbits surface-particles from bottom.
b = breadth of orbits of surface-particles.
h = height of orbits of surface-particles.
t = periodic time of wave in seconds.
x = natural number corresponding to hyperbol. log. of $\frac{2\pi d}{l}$.
g = accelerating force of gravity = 32·2.

$$\left.\begin{aligned} v &= \sqrt{\frac{gLh}{2\pi b}} = V\sqrt{\frac{h}{b}} = \frac{l}{t} \\ t &= \sqrt{\frac{2\pi Lb}{gh}} = \frac{l}{v} \end{aligned}\right\} \text{where } d \text{ exceeds } \tfrac{1}{36} \text{ of } l.$$

$$v = \sqrt{gd} \quad . \quad . \quad . \quad . \quad . \quad \text{where } d \text{ is less than } \tfrac{1}{36} \text{ of } l.$$

$$b = h\left(\frac{x+\frac{1}{x}}{x-\frac{1}{x}}\right) \qquad h = b\left(\frac{x-\frac{1}{x}}{x+\frac{1}{x}}\right) \qquad \frac{h}{b} = \frac{x-\frac{1}{x}}{x+\frac{1}{x}} = \frac{L}{l}$$

$$l = \frac{Lb}{h}\left\{\begin{array}{l}\text{where } d \text{ exceeds} \\ \tfrac{1}{36} \text{ of } l.\end{array}\right. \qquad l = \frac{L+2\pi d}{2}\left\{\begin{array}{l}\text{where } d \text{ is less} \\ \text{than } \tfrac{1}{36} \text{ of } l.\end{array}\right.$$

TABLE OF THE RATIOS OF WAVES FOR SHALLOW WATER TO THE CORRESPONDING QUANTITIES FOR DEEP WATER.

Depth of Water from Centres of Orbits in Fractions of Wave's Length	RATIOS			Depth of Water from Centres of Orbits in Fractions of Wave's Length	RATIOS		
	Velocity for a given Length	Length and Velocity for a given Period	Length for a given Velocity		Velocity for a given Length	Length and Velocity for a given Period	Length for a given Velocity
$\frac{1}{36}$	·417	·174	5·76	$\frac{6}{36}$	·884	·781	1·28
$\frac{2}{36}$	·579	·336	2·98	$\frac{8}{36}$	·940	·884	1·13
$\frac{3}{36}$	·693	·481	2·08	$\frac{10}{36}$	·969	·939	1·06
$\frac{4}{36}$	·776	·603	1·66	$\frac{12}{36}$	·985	·970	1·03
$\frac{5}{36}$	·838	·703	1·42	$\frac{15}{36}$	·995	·989	1·01

ROLLING.

Isochronous Rolling in Still Water.

τ = periodic time of unresisted oscillation, or double roll, in seconds.
τ_1 = periodic time of resisted double roll in seconds.
M = height of metacentre above centre of gravity in feet.
I = transverse moment of inertia of weight of ship.
n = number of double rolls a vessel actually makes in time t in seconds.
θ = greatest angle of heel at commencement of time t in circular measure.
θ_1 = diminished angle of heel at end of time t in circular measure.

$$c=\left(\frac{\text{hyp log }\theta-\text{hyp log }\theta'}{t}\right)=\left(\frac{\log\theta-\log\theta'}{\cdot 4343t}\right)=\frac{gl}{2r^2}.$$

h = height of equivalent pendulum in feet for unresisted rolling. For resisted rolling substitute τ_1 for τ.
r = transverse radius of gyration in feet.
m = moment of righting couple at angle $\theta = \text{M}\times\text{D}\times\theta$, where θ is expressed in circular measure.
D = displacement in tons, i.e. weight of the ship.
l = length of leverage of keel resistance in feet.
g = accelerating force of gravity = 32·2 nearly.

$$\tau=\sqrt{\frac{4\pi^2r^2}{g\text{M}}}=\frac{2\pi r}{\sqrt{g\text{M}}}=\sqrt{\frac{r^2}{\cdot 8154\text{M}}}=\sqrt{\frac{4\pi^2h}{g}}=\sqrt{\frac{h}{\cdot 8154}}=\sqrt{\frac{\tau_1^2}{1+\frac{c^2\tau_1^2}{39\cdot 48}}}$$

$$\tau_1=\frac{t}{n}=\frac{2\pi}{\sqrt{\left\{\frac{g\text{M}}{r^2}-\frac{g^2l^2}{4r^4}\right\}}}=\frac{\sqrt{\frac{r^2}{\cdot 815\text{M}}}}{\sqrt{\left(1-\frac{gl^2}{4\text{M}r^2}\right)}}$$

$$r^2=\frac{g\text{M}\tau^2}{4\pi^2}=\cdot 815\text{M}\tau^2=\frac{g\text{M}}{\frac{4\pi^2}{\tau_1^2}+c^2}=\frac{\cdot 815\text{M}\tau_1^2}{1+\frac{c^2\tau_1^2}{39\cdot 48}}$$

$$h=\frac{r^2}{\text{M}}=\frac{g\tau^2}{4\pi^2}=\cdot 815\tau^2=\frac{\text{I}\times\theta}{m}$$

$$l=\frac{2cr^2}{g}=\frac{cr^2}{16\cdot 1}=\frac{2\text{M}c}{\frac{4\pi^2}{\tau_1^2}+c^2}$$

Note.—The equivalent pendulum is one whose time of revolution is the same with the period of oscillation, or double roll.

A compound pendulum has not only the same period of oscillation, but the same statical and dynamical stability.

GEOMETRICAL ILLUSTRATION OF (i) $\tau^2 = \frac{h}{\cdot 8154} = 1{\cdot}23h$, (ii) $h \,.\, \mathrm{M} = r^2$.

BY J. MACFARLANE GRAY, ESQ.

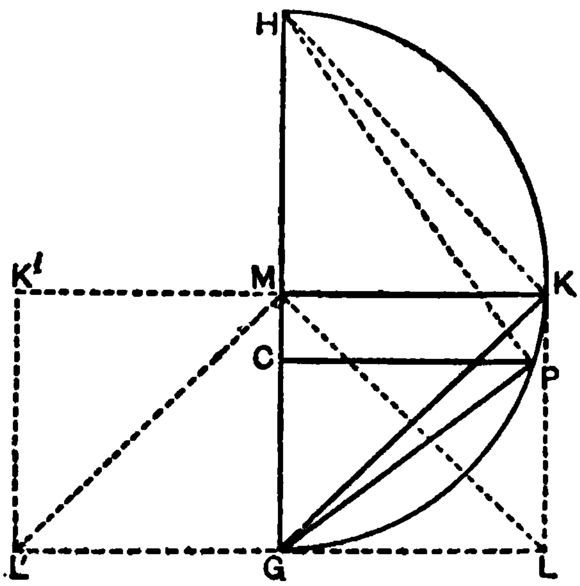
(*From Transactions of the Institution of Naval Architects*, 1897.)

In fig. 173 HKPG is a semicircle and HG its diameter. GC is a constant $=1{\cdot}23$ on any convenient scale, GP the period of the double roll in seconds, GK the radius of gyration in feet, GM the height of the metacentre in feet, GH the height of the equivalent pendulum in feet—all on the same scale as GC. Then by elementary geometry,

$\mathrm{GP}^2 = \mathrm{GC} \,.\, \mathrm{GH}$, and $\mathrm{GK}^2 = \mathrm{GM} \,.\, \mathrm{GH}$;
that is

$$\tau^2 = 1{\cdot}23h, \text{ and } r^2 = \mathrm{M}h.$$

FIG. 173.



COMPOUND PENDULUM.

In the same figure produce KM to MK′, making MK′ equal to KM. On KK′ describe a rectangle KLL′K′ passing through G. Join ML and ML′. The triangular frame ML′L hung at the point M will represent the required compound pendulum, supposing it to be loaded at each of the two points L and L′ with one-half the weight of the ship.

TO INCREASE THE LENGTH OF A SHIP'S TRANSVERSE RADIUS OF GYRATION.

RULE.—Shift a pair of equal weights, situated with their centres of gravity at equal distances from the middle line and on opposite sides, further out from the middle line and through equal distances.

W = weight of ship. w = either of the weights.
d = original distance of centres of gravity of w from middle line.
d' = new distance of centres of gravity of w from middle line.
r = original radius of gyration.
r' = new radius of gyration.
Increase of radius of gyration, $r' - r = \sqrt{\left[\frac{2w(d'^2 - d^2)}{\mathrm{W}}\right]}$

To find the increase of the radius of gyration.

RULE.—From the square of the new distance of the centre of gravity of either weight from the middle line, subtract the square of the original distance; multiply the remainder by the sum of the shifted weights and divide by the weight of the ship: the square root of the quotient will be the increase of the ship's transverse radius of gyration.

ISOCHRONOUS ROLLING.

In a true isochronous rolling ship her righting moment at any angle of heel is exactly proportional to the angle of disturbance, and her metacentric evolute is the involute of a circle described about the centre of gravity and through the metacentre; and consequently the metacentric involute is the involute of the involute of that circle.

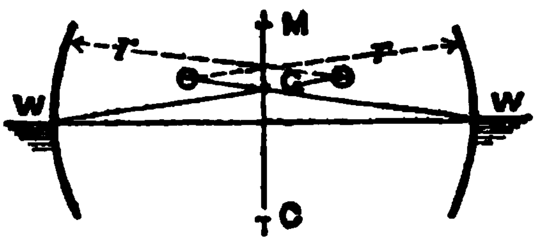
M = height of metacentre above centre of gravity.
m = height of metacentre above centre of buoyancy.
m' = radius of curvature of metacentric involute when the angle of heel is θ (in circular measure).
y = half-breadth of upright water-section.
y' = half-breadth of inclined water-section for the angle of heel θ.

$$m' = m + \frac{M\theta^2}{2}$$

$$y' = y\left(1 + \frac{M\theta^2}{2m}\right)^{\frac{1}{3}}.$$

To approximate to the form of cross section between wind and water of a true isochronous rolling ship.

FIG. 174.



In fig. 174 let M be the metacentre, G the centre of gravity, WW the upright water-plane, C the centre of buoyancy.

Draw the two lines W, G, and produce them beyond G to ⊙, making G⊙ = WG$\frac{GM}{3CM}$; then the two points ⊙ will be the centres of curvature for the circular arcs through the points W, W.

d = height of G above WW.
r = W⊙.

$$r = \sqrt{y^2 + d^2}\left(1 + \frac{M}{3m}\right).$$

Note.—The same notation is used as in the foregoing formula.

PERIOD OF DIPPING.

D = volume of displacement in cubic feet.
A = area of load water-plane in square feet.
τ = periodic time of a complete dipping oscillation in seconds.
h = height of equivalent pendulum in feet.
g = accelerating force of gravity = 32·2 nearly.

$$\tau = 2\pi\sqrt{\frac{D}{Ag}} = \sqrt{\frac{h4\pi^2}{g}} = \sqrt{\frac{h}{\cdot 8154}}.$$

ROLLING AMONG WAVES.

General Conclusions. (*Rankine.*)

1. The stability of a ship tends to keep her upright to the effective wave-surface—that is, the subsurface of the wave which, in an ordinary vessel, may generally be taken as traversing her centre of buoyancy.

2. The permanent rolling of a ship of very great stability and little keel resistance, is governed by the motion of the effective wave-surface, so that she will roll *with the waves*, or like a raft.

3. When the period of unresisted rolling is to the wave period as $\sqrt{2} : 1$, the permanent rolling is wholly governed by the motion of the originally vertical columns of water; so that she will roll *against the waves*, like a board of no stability floating edgewise.

Note.—In the preceding cases, the vessel is upright when the trough or crest of a wave passes her, and her greatest angle of heel is equal to the steepest slope of the effective wave-surface.

4. When the period of a ship's unresisted rolling is less than the above value, her upright positions occur *before* the arrival of the troughs and crests of the waves, and her greatest angle of heel is *greater* than the steepest slope of the effective wave-surface.

5. When the period of a ship's unresisted rolling is equal to that of the waves, the greatest angle of permanent rolling occurs, and it exceeds the slope of the waves in a proportion which is the greater the less the keel resistance, and which becomes infinite when the keel resistance vanishes.

6. When the period of unresisted rolling of a vessel exceeds that of the waves in a greater ratio than that of $\sqrt{2} : 1$, her upright positions occur *after* the arrival of the troughs and crests of the waves, and her angle of heel is *less* than the greatest slope of the waves.

7. The most unfavourable proportions for the periodic time of free rolling to that of forced or passive rolling being those which lie near or between equality and $\sqrt{2} : 1$.

8. A period of free rolling much less than that of passive rolling gives great stiffness; and a period of free rolling exceeding $\sqrt{2}$ times that of passive rolling is favourable to steadiness, provided that this lengthened period be produced by the inertia of the ship and not by insufficient statical stability.

Table giving the Periods of Oscillation of Ships.

English Navy				French Navy			
Name	Oscills. per Min.	Mean Roll in Degrees	Heights of GM in Feet	Name	Oscills. per Min.	Mean Roll in Degrees	Heights of GM in Feet
Northumberland	4·0	7·0	1·99	Solférino .	9·75	17·14	4·5
Agincourt . .	7·8	7·5	1·99	Magenta .	10·0	18·00	5·05
Monarch . .	6·0	5·0	2·37	Napoléon .	10·5	18·56	4·92
Inconstant .	6·0	4·0	2·8	Couronne .	12·0	18·84	5·57
Captain . .	7·0	3·7	2·60	Tourville .	10·75	20·28	5·31
Hercules . .	9·0	4·5	2·69	Invincible .	12·0	20·73	6·36
Warrior . .	8·0	16·0	4·68	Normandie .	12·5	21·92	6·59
Prince Consort .	11·25	11·75	6·01	Talisman .	15·0	—	—

PROPULSION OF VESSELS.

Wave Water-lines.

The entrance of a pure wave water-line is a curve of versed ines, and the run trochoidal, the length of entrance being in roportion to the run as 3 : 2, and for a given speed there should .lso be a fixed proportion between that speed and the length of ntrance and run, which can be obtained from the following able or from the following formulæ.

V = velocity of ship in knots per hour.
E = length of entrance in feet. $E = \cdot 562V^2$.
R = length of run in feet. $R = \cdot 375V^2$.

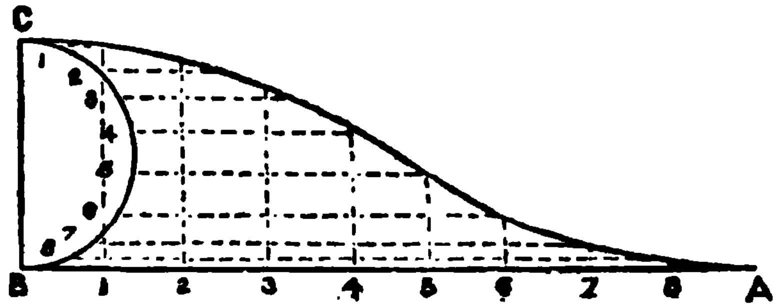
Table giving the Length of Entrance and Run of Wave Water-lines for a Given Speed.

Speed in Knots per Hour	Length of Entrance in Feet	Length of Run in Feet	Speed in Knots per Hour	Length of Entrance in Feet	Length of Run in Feet
1	·562	·375	11	68·00	45·38
2	2·248	1·500	12	80·93	54·00
3	5·058	3·375	13	94·98	63·38
4	8·992	6·000	14	110·15	73·50
5	14·050	9·375	15	126·45	84·38
6	20·232	13·500	16	143·87	96·00
7	27·538	18·375	17	162·42	108·38
8	35·968	24·000	18	182·09	121·50
9	45·522	30·375	19	202·88	135·38
10	56·200	37·500	20	224·80	150·00

Note.—There may be any length of parallel middle body.

Method of Construction of Entrance of Wave-line.

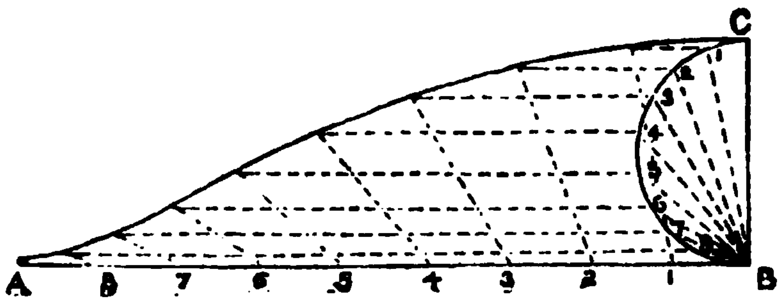
FIG. 175.



Let AB = length of entrance, and BC the diameter of semicircle = the half-breadth; divide the length AB into the same number of equal parts as the circumference of the semicircle; then through the points of division of the semicircle draw lines parallel to AB and cutting other lines drawn through the points of division of AB and perpendicular to it: the intersection of the horizontal with the respective vertical lines will give points in the curve.

Method of Construction of Run of Wave-line.

FIG. 176.



Divide the length of the run AB and the semicircle on the half-breadth BC into the same number of equal parts; in the semicircle draw the chords B8, B7, B6, &c., and through the points of division on AB draw lines parallel to them: then the points of intersection of those lines with the respective lines drawn through the points of division of the semicircle, and parallel to the base AB, will be points in the curve.

Rapid Methods of Calculating Wetted Surfaces.

By A. Denny, Esq.

(*From Transactions of the Institution of Naval Architects*, 1895.)

(i.) Mumford's formula, based on Kirk's analysis

$$S = (L \times D \times 1{\cdot}7) + (L \times B \times C).$$

(ii) Froude's 'No. 8' formula, $S = L\{1{\cdot}52D + ({\cdot}374 + {\cdot}85C^2)B\}$.

(iii) Froude's 'No. 9' formula, $S = L\{1{\cdot}5D + ({\cdot}09 + C)B\}$.

where S = Wetted surface in square feet.

L = Length between perpendiculars in feet.

D = Moulded draught in feet.

B = Moulded beam in feet.

C = Block coefficient.

NORMAND'S APPROXIMATE FORMULA FOR THE DISTANCE OF THE CENTRE OF BUOYANCY BELOW THE LOAD WATER-LINE.

(*Given in Transactions of the Institution of Naval Architects, 1892, by Mr. S. W. F. Morrish.*)

$$\text{Centre of buoyancy below L.W.L.} = \frac{1}{3}\left(\frac{d}{2} + \frac{V}{A}\right),$$

where V = Volume of displacement in cubic feet.
A = Area of load water plane in square feet.
d = Mean draught to top of keel in feet.

APPROXIMATE METHOD OF DETERMINING THE MEAN GIRTH OF SHIPS.

BY A. BLECHYNDEN, M.I.N.A.

(*From Transactions of the Institution of Naval Architects,* 1888.)

Let M = Midship wetted girth measured on midship section in feet.
L = Length between perpendiculars in feet.
D = Displacement in cubic feet.
S = Midship section in square feet.
d = Moulded draught in feet.
c = Prismatic coefficient of fineness $= \frac{D}{L \times S}$.
m = Mean girth in feet $m = \cdot 95\, CM + 2(1 - C)d$.

TABLE OF RESISTANCE IN LBS. TO ONE SQUARE FOOT OF FLAT-FRONTED VESSEL, AND HORSE-POWER REQUIRED TO PROPEL IT AT VARIOUS SPEEDS.

Ft. per Sec.	Resistance	Horse-power	Miles an Hour	Resistance	Horse-power	Knots an Hour	Resistance	Horse-power
1	1	0·00182	1	2·15111	0·00574	1	2·85235	0·00876
2	4	0·01455	2	8·60444	0·04589	2	11·40938	0·07007
3	9	0·04909	3	19·36000	0·15488	3	25·67111	0·23649
4	16	0·11636	4	34·41778	0·36712	4	45·63754	0·56056
5	25	0·22727	5	53·77778	0·71704	5	71·30865	1·09484
6	36	0·39273	6	77·44000	1·23904	6	102·68445	1·89188
7	49	0·62364	7	105·40444	1·96755	7	139·76495	3·00424
8	64	0·93091	8	137·67111	2·93698	8	182·55014	4·48446
9	81	1·32545	9	174·24000	4·18176	9	231·04003	6·38511
10	100	1·81818	10	215·11111	5·73629	10	285·23460	8·75872
11	121	2·42000	11	260·28444	7·63463	11	345·13387	11·65786
12	144	3·14182	12	309·76000	9·91231	12	410·73780	15·13506
13	169	3·99455	13	363·53778	12·60263	13	482·04647	19·24290
14	196	4·98909	14	421·61778	15·74038	14	559·05980	24·03392
15	225	6·13636	15	484·00000	19·35998	15	641·71785	29·56068

SPEED FORMULÆ AS GENERALLY USED FOR STEAM VESSELS.

v=velocity in knots per hour.
H=indicated horse-power for V speed.
D=displacement in tons.
k=sectional coefficient of performance.
V_1=any other velocity in knots per hour.
H_1=indicated horse-power for V_1 speed.
X=area of midship section in square feet.
x=displacement coefficient of performance.

$$V=\sqrt[3]{\frac{H\times k}{X}} \qquad H=\frac{V^3\times X}{k} \qquad k=\frac{V^3\times X}{H} \qquad V_1=V\sqrt[3]{\frac{H_1}{H}}$$

$$V=\sqrt[3]{\frac{H\times x}{D^{\frac{2}{3}}}} \qquad H=\frac{V^3\times D^{\frac{2}{3}}}{x} \qquad x=\frac{V^3\times D^{\frac{2}{3}}}{H} \qquad H_1=\left(\frac{V_1}{V}\right)^3 H.$$

NOTE.—These formulæ may be taken as sufficiently accurate up to 12 knots speed, when from 12 knots and upwards V^4 and even V^5 may be substituted at high speeds for V^3.

In the following tables let—
S=slip in knots per hour.
D=displacement in tons.
L=length of vessel in feet.
V=velocity in knots per hour.
H=indicated horse-power.
X=area of midship section in square feet.
B=breadth of vessel in feet.

TABLE OF COEFFICIENTS OF PERFORMANCE, ETC., OF SOME OF HER MAJESTY'S SCREW VESSELS.

Name of Vessel	L	$\frac{L}{B}$	X	D	H	V	S	$\frac{H}{X}$	$\frac{H}{D^{\frac{2}{3}}}$	$\frac{V^3\times X}{H}$	$\frac{V^3\times D^{\frac{2}{3}}}{H}$
Agincourt . .	400 0	6·73	1185	9071	6867	15·433	Neg.	5·79	15·79	634·3	232·8
" . .	400 0	6·73	1198	9152	5971	13·879	Neg.	4·99	13·65	536·1	195·9
" . .	400 0	6·73	1198	9152	3001	10·998	Neg.	2·51	6·86	530·8	194·0
Minotaur . .	400 0	6·69	1158	8800	6396	14·779	Neg.	5·47	14·87	590·0	217·2
" . .	400 0	6·69	1158	8800	3451	12·387	Neg.	2·98	8·10	637·7	234·7
" . .	400 0	6·69	1313	10185	3497	11·842	Neg.	2·66	7·44	623·6	223·1
Achilles . . .	380 0	6·52	1120	7895	5035	14·358	Neg.	4·50	12·7	658·5	233·1
" . . .	380 0	6·52	1293	9862	4818	13·349	Neg.	3·73	10·85	638·4	219·3
" . . .	380 0	6·52	1308	9487	3205	12·049	Neg.	2·45	7·15	713·7	244·6
" . . .	380 0	6·52	1284	9258	2081	11·132	Neg.	2·09	6·08	660·8	226·9
Warrior . . .	380 0	6·55	1219	8852	5469	14·356	1·705	4·49	12·78	659·4	231·5
" . . .	380 0	6·55	1260	9214	5092	13·936	1·636	4·04	11·59	669·7	233·6
" . . .	380 0	6·55	1219	8852	2867	12·174	1·000	2·35	6·70	767·1	269·3
" . . .	380 0	6·56	1219	8852	1988	11·040	·210	1·63	4·65	824·9	289·6
" . . .	380 0	6·55	1255	9180	2777	10·415	1·371	2·21	6·33	510·6	178·4
Euphrates . .	360 0	7·33	814	5898	2084	11·523	·331	2·56	6·39	597·5	239·6
" . .	360 0	7·33	841	6109	1082	10·600	·586	2·14	5·39	555·8	220·8
Serapis . . .	360 0	7·33	778	5800	3945	14·059	2·645	5·07	12·51	548·0	222·1
" . . .	360 0	7·33	804	5816	3698	13·378	Neg.	4·60	11·43	530·5	209·4
" . . .	360 0	7·33	778	5600	2613	12·551	1·616	3·36	8·29	589·1	238·8
Inconstant . .	337 4	6·71	900	5328	7361	16·513	1·188	8·18	24·13	550·46	186·6
" . .	337 4	6·71	900	5328	3531	13·701	·498	3·92	11·57	655·61	222·2
Sultan . . .	325 0	5·51	1320	8714	8629	14·134	2·864	6·54	20·38	431·9	138·6
Captain * . .	320 0	6·01	1176	7672	5990	14·239	1·665	5·09	15·40	566·8	187·5
" . .	320 0	6·01	1174	7655	2908	11·697	·693	2·47	7·49	646·0	213·7
Bellerophon . .	300 0	5·36	1065	6372	5966	14·227	Neg.	5·60	17·36	514·1	165·9
" . .	300 0	5·36	1018	5700	4708	13·646	Neg.	4·63	14·75	549·2	172·2
" . .	300 0	5·36	1065	6372	3119	12·103	·172	2·93	9·08	605·3	195·3
" . .	300 0	5·36	1134	6854	2984	11·780	·133	2·63	8·27	621·3	197·7
Orontes . . .	300 1	6·72	644	3400	1323	10·890	1·631	2·05	5·85	628·6	220·7
" . . .	300 1	6·72	781	4249	1081	9·755	1·779	1·38	4·12	670·6	225·3
" . . .	300 1	6·72	796	4321	775	8·719	1·519	·97	2·92	681·0	226·8
Raleigh . . .	298 0	6·14	851	4647	6518	15·504	3·945	7·24	22·11	515·0	168·5
" . . .	298 0	6·14	851	4647	3414	13·457	1·940	4·01	12·26	607·5	198·8
Devastation * .	285 0	4·58	1472	9190	6652	13·840	·994	4·52	15·16	586·6	174·8
" .	285 0	4·58	1472	9190	3399	11·909	·200	2·31	7·75	731·4	218·0
Adventure . .	282 10	7·77	467	2432	1227	11·447	1·796	2·62	6·78	571·0	221·1
" . .	282 10	7·77	474	2470	1053	10·617	1·945	2·22	5·76	538·6	207·6
" . .	282 10	7·77	467	2432	637	9·256	·948	1·36	3·52	581·7	225·2
" . .	282 10	7·77	436	2248	517	8·507	1·534	1·19	3·01	519·5	204·5
Audacious * . .	280 0	5·18	997	5594	4835	13·401	·295	4·85	15·34	496·3	156·9
" . .	280 0	5·18	1087	6170	4021	12·829	·401	3·70	11·95	570·8	176·6
" . .	280 0	5·18	997	5594	2946	10·811	3·017	2·96	9·35	427·6	135·1
" . .	280 0	5·18	997	5594	1703	10·091	Neg.	1·71	5·40	601·6	190·2
Active . . .	270 0	6·43	632	3057	4015	14·966	1·931	6·35	19·06	527·5	175·8
" . . .	270 0	6·43	628	3033	3500	14·877	2·650	5·54	16·61	594·5	198·3
" . . .	270 0	6·43	632	3057	2046	12·295	·773	3·24	9·71	573·9	191·3
" . . .	270 0	6·43	628	3033	1693	11·765	1·241	2·68	8·03	608·0	202·8
Repulse . . .	252 0	4·27	1170	6010	3347	12·284	3·947	2·86	10·12	648·0	183·1

* Twin screw vessels.

NOTES ON SHIP RESISTANCE.

Vis inertia to motion is energy or way stored up.

Momentum gained is given out again after propelling power has ceased to act.

Weight gives uniformity of motion, and for that reason tugs or towing vessels should have weight rather than fine lines and light displacement.

Velocity is obtained by engine overcoming resistance, and acceleration goes on till the whole power is absorbed in overcoming the internal and external resistances.

Resistance may be divided as follows:—

(1) Skin or frictional resistance.
(2) Eddy-making resistance due to wave.
(3) Wave-making resistance.

Number two is generally very small, and numbers two and three may be classed together and termed 'residuary resistance.'

No sensible error is involved in calculating the skin resistance upon the hypothesis that the immersed skin is equivalent to that of a rectangular surface of equal area, and length (in line of motion) equal to that of the vessel.

Frictional resistance varies nearly as the square of the speed, or more accurately, at the 1·825 power for properly designed vessels.

The coefficient of skin friction increases as the length decreases from 50 feet and downwards; above 50 feet there is no material increase for varnished surfaces. Froude gives ·3 lb. per square foot for under 50 feet, and ·25 lb. per square foot above 50 feet may be taken, at a speed of 6 knots per hour.

The water should be displaced and replaced gradually to minimise wave-making and eddy resistance, as this depends upon form and speed.

The lines and length of a vessel should be so formed that the energy lost by the bow wave should be nearly regained by the stern wave coming at the quarter at her designed speed.

In well-formed vessels power is proportional to wetted skin.

Form and wetted surface to some extent depends on displacement, so that resistance was found to vary roughly as $\sqrt[3]{\text{displacement}^2}$, and also as the speed^2 and indicated horse-power varies as displacement$^{\frac{2}{3}}$ and velocity^3.

HP	= indicated horse-power.	V	= velocity in feet per minute.
R	= resistance in lbs.	K	= constant for unity.
D	= displacement in lbs.	E	= efficiency of engine.

$\text{R} = D^{\frac{2}{3}} \times V^2 \times K \qquad \text{R} \times V = D^{\frac{2}{3}} \times V^3 \times K$

$$\text{IHP} = \frac{D^{\frac{2}{3}} \times V^3 \times K}{33000 \times E}.$$

When displacement is in tons and velocity is in knots per hour

$$\text{IHP} = \frac{D^{\frac{2}{3}} \times V^3 \times 60 \times K}{2240 \times 6080 \times 33000 \times E} = \frac{D^{\frac{2}{3}} \times V^3}{C},$$

$$\text{when } C = \frac{60 \times K}{2240 \times 6080 \times 33000 \times E}.$$

Note.—The wetted surface varying as the square of the cube root of the displacement is based upon the relation of the displacement of a cube fully immersed to that of the area of its five wetted sides,

Let L = length of edge of cube,
D = displacement,
W = wetted surface,
then $D = L^3 \quad L = \sqrt[3]{D}$
and $W = 5 \times L^2 = 5\sqrt[3]{D^2}$.

EXPERIMENTS UPON THE EFFECT PRODUCED ON THE WAVE-MAKING RESISTANCE OF SHIPS BY LENGTHS OF PARALLEL MIDDLE BODY (W. FROUDE, M.I.N.A.).

The models of the ships from 480 to 280 feet long inclusive were made to a scale of $\frac{1}{32}$ full size, and those from 240 to 160

feet on a $\frac{1}{16}$ scale, only two models being used; the length of middle body was put in as required for each experiment.

The principal dimensions were as follows :—

Length.				Breadth Extreme	Draught of Water	Dispt.
Fore Body	After Body	Middle Body	Total			
Feet	Feet	Feet.	Feet	Feet	Feet	Tons
80	80	320	480	38·4	14·4	5794·0
80	80	280	440	38·4	14·4	5225·5
80	80	240	400	38·4	14·4	4657·0
80	80	200	360	38·4	14·4	4088·5
80	80	160	320	38·4	14·4	3520·0
80	80	120	280	38·4	14·4	2951·5
80	80	80	240	38·4	14·4	2383·0
80	80	40	200	38·4	14 4	1814·5
80	80	0	160	38·4	14·4	1246·0

Comparing the resistances of the various ships at low speeds, we find that for every 40 feet of length added the resistance is increased in proportion; but at the higher speeds this similarity disappears, and a shorter ship will have greater total resistance than a longer one, and at still higher speeds fall below it again.

Now regarding the resistance of a ship as made up of three items, viz. skin friction, eddy-making resistance, and wave-making resistance, and taking the former as proportional to the area of skin, so that addition of successive equal increments of parallel side can only affect it to the extent of producing equal increments for every additional length, the anomalies we have noticed can only be the result of the effect produced by the different distance between the ends on the other two items which make up the total resistance.

Fig. 178 shows these resistances separated, the skin friction being measured below the base line and the wave-making resistance above; distances along the base line represent the lengths of ships, and the corresponding ordinate shows the resistances at the various speeds.

Considering the curves of wave-making resistance only, we see that up to a speed of about 11 knots they are straight and level, but at higher speeds they present a series of regular undulations, showing that the gradual insertion of parallel side produces an alternate increase and diminution in the wave-making resistance.

These undulations present the following characteristics :—

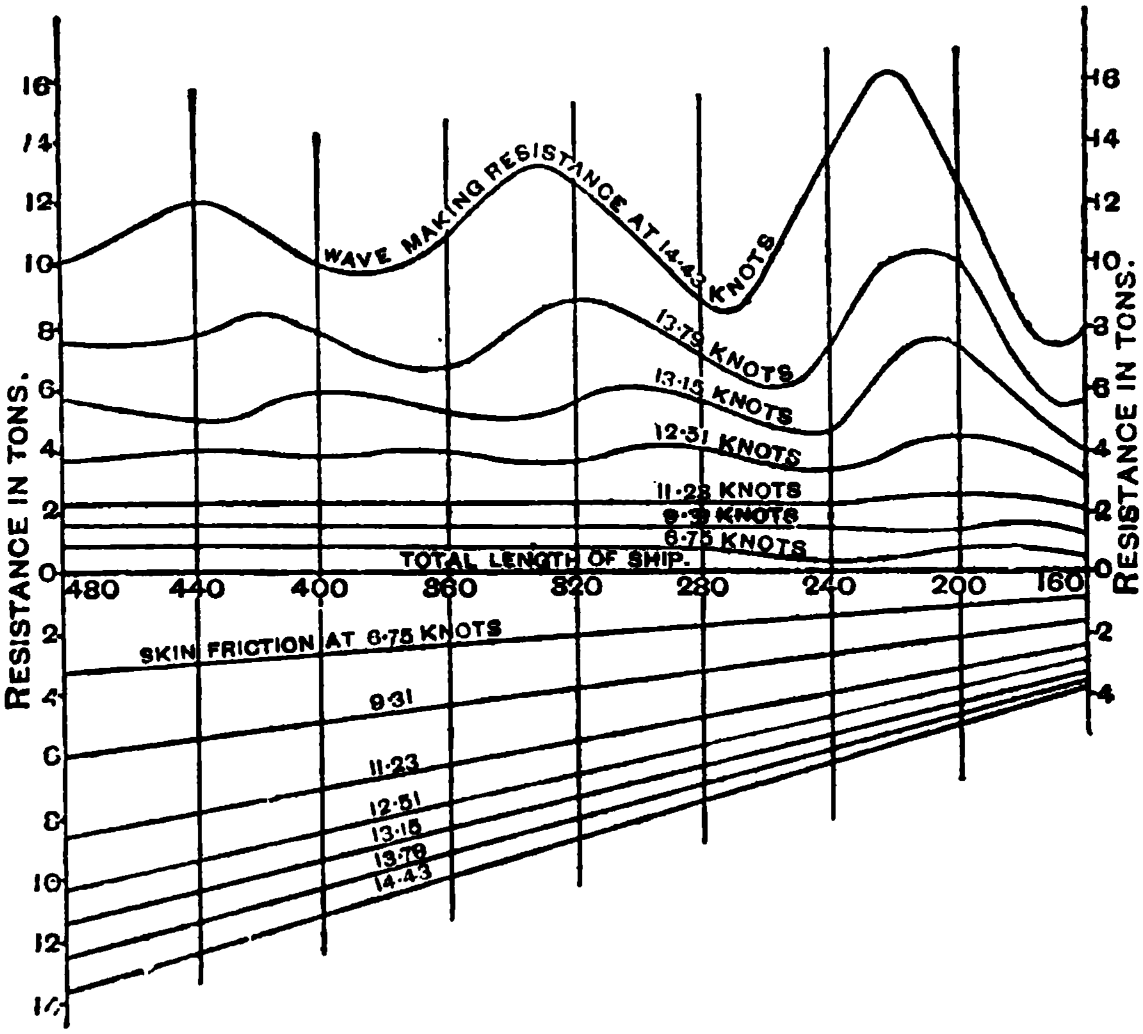
1. The spacing or length of the undulation appears uniform throughout each curve.

2. The spacing is more open in the curves of higher speeds, the lengths being apparently about proportional to the square of the speed.

3. The amplitudes, or heights of the undulations, are greater in curves of higher speeds.

4. The amplitude in each curve diminishes as the length of parallel side increases.

FIG. 178.



In the experiments the 500 feet ship was accompanied by a wave system with crests at distances of 125 feet, 235 feet, and 350 feet from the bow; and troughs 180 feet, 295 feet, and 410 feet from the bow, showing that when the ship had a minimum wave resistance there was a crest about 40 feet from the stern, and when a maximum resistance there was a wave trough about 40 feet from the stern, that is, about the middle of the after body; so that the undulations in the wave-making resistance are due to the variations of quasi-hydrostatic pressure against the after body, there being a comparative excess of pressure (causing a forward force or diminution of resistance) when the after body is opposite a crest, and the reverse when it is opposite a trough.

From a paper read at the Institution of Naval Architects, 1881, by R. E. Froude, M.I.N.A., it appears that the wave-making features of a ship will operate more effectively to make short waves if their displacement is disposed breadwise rather than deepwise, and more effectively to make long waves if it is disposed deepwise rather than broadwise. Now the diverging

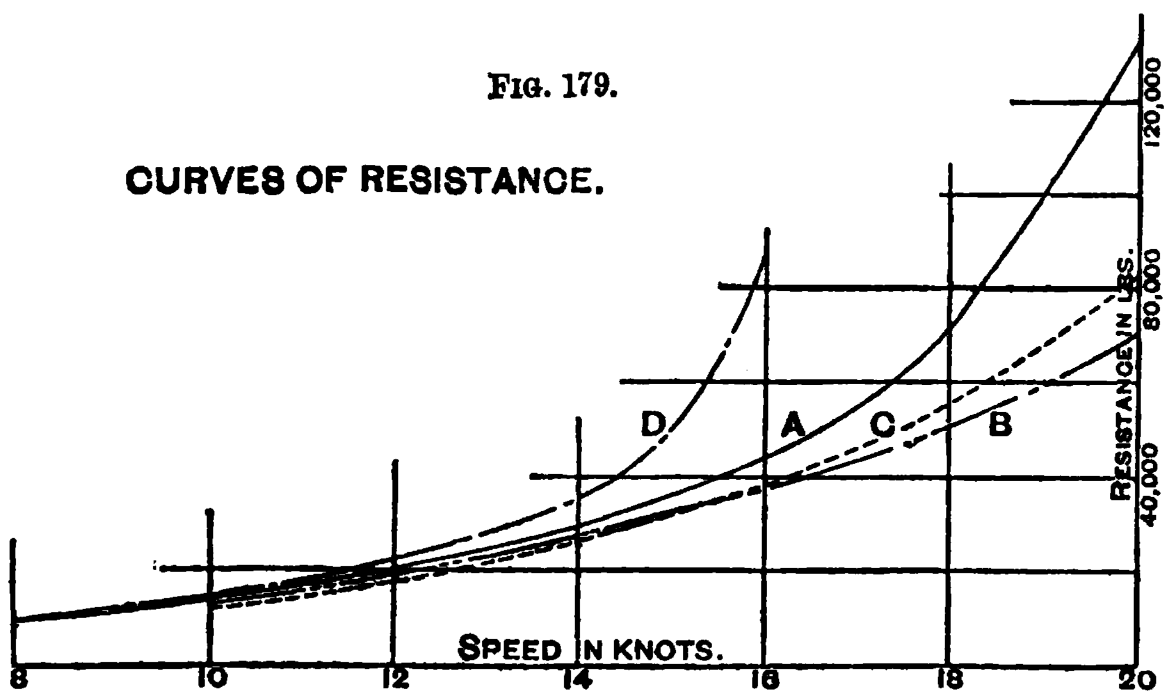
waves being necessarily much shorter than the transverse waves, we see that flaring out the end sections of a ship, or increasing the ratio of breadth to depth, will tend to increase the resistance due to diverging waves and diminish that due to transverse waves; while the U sections, or increasing ratio of depth to breadth, has the opposite effect. The experiments showed that as a rule moderately U shaped sections are good for the fore-body, and comparatively V shaped sections for the after-body. This would seem to show that in the wave-making tendency of after-body the diverging wave element is less formidable than in that of the fore-body.

On the Comparative Resistance of Long Ships of Several Types. (By W. Froude, M.I.N.A.)

(Taken from the *Transactions of the Institution of Naval Architects*, 1876.)

Name of ship	Displacement.	Length: Entrance	Length: Parallel middle body	Length: Run	Length: Total	Extreme breadth	Mean draught	Area of skin	Square root of entrance plus run	Total resistance	Resistance due to skin friction alone	Residuary resistance independent of skin	Doubled skin friction	Total resistance with skin friction doubled	
	tns.	ft.	ft.	ft.	ft.	ft.	ft.	sq. ft	ft.	lbs.	lbs.	lbs.	lbs.	lbs.	Assumed speed 12 knots
A	3960	144	72	144	360	37·2	16·25	18660	17·08	20000	15600	4400	31200	35600	
B	3960	179·5	—	179·5	359	45·88	18·00	19180	18·95	19220	16160	3060	32320	35380	
C	3960	154·5	—	154·5	309	49·4	19·82	17810	17·58	18700	14890	3810	29780	33590	
D	3960	95	95	95	285	45·56	17·89	16950	18·78	21100	14250	6850	28500	35350	

Fig. 179.



At a speed of 12 knots the resistances of these vessels 'varying greatly in their relative proportions' differ by only 10 per

cent. At a speed of 16 knots B and C, with no middle-body, show a superiority which increases with the speed.

At very low speeds compared with the length of the ships, say from 5 to 8 knots, the surface friction is about 92 per cent. of the whole resistance.

If the surface friction were doubled, a result that may occur towards the end of a long voyage, then it will be seen that the shorter ships C and D gain an advantage due to having smaller wetted surfaces.

On the 'Constant' System of Notation of Results of Experiments on Models used at the Admiralty Experiment Works. (By R. E. Froude, M.I.N.A.)

(From *Transactions of the Institution of Naval Architects*, 1888.)

The method may be described as follows:—The proportions, and to some extent the lines, of the hull are characterised by numerical values and diagrams, representing not absolute measurements of hull, but measurements stated in terms of a unit-dimension proportional to the cube root of displacement. The performance is characterised by two so-called 'constants' designated K and C, of which the former denotes speed in terms of a unit speed proportional to the sixth root of the displacement, while the latter denotes corresponding resistances (or horsepowers) in the form of the reciprocal of what is known as the Admiralty displacement constant.

The hull dimensions are expressed in terms of a linear unit or standard dimension proportionate to the cube root of the displacement. For this unit-dimension take the length of the side of the cube having content equal to the displacement of hull $= U$,

$$\text{then } U = D^{\frac{1}{3}}.$$

For the speed which is to make $K =$ unity, the speed is selected having wave-length $= \frac{U}{2}$. Hence, if V, g and D are expressed in corresponding units of foot seconds and in feet, the true value of $K = \frac{V}{D^{\frac{1}{6}}}\sqrt{\frac{4\pi}{g}}$.

And in order to get rid of decimal cyphers in the value of C it is multiplied by 1,000, so that $C = \frac{R}{DK^2} \times 1000$.

The shape and proportions of the hull are indicated in fig. 181. The readings of the lines and figures given denote not absolute linear dimensions, but the ratios of these dimensions to the linear unit $U = D^{\frac{1}{3}}$, in corresponding content units. In the same manner surface areas are expressed by the ratios of those areas to $U^2 = D^{\frac{2}{3}}$ in corresponding content units,

To make the correction for skin friction in the C value, let the skin friction term in the resistance $=f$, and the corresponding term in the C value $=$ F. Then $F=\frac{f}{D^{\frac{2}{3}}}\times 1000$.

FIG. 180.

CONSTANT CURVE (CORRECTED FOR SKIN FRICTION FOR SHIP 300 FT. LONG)

}*

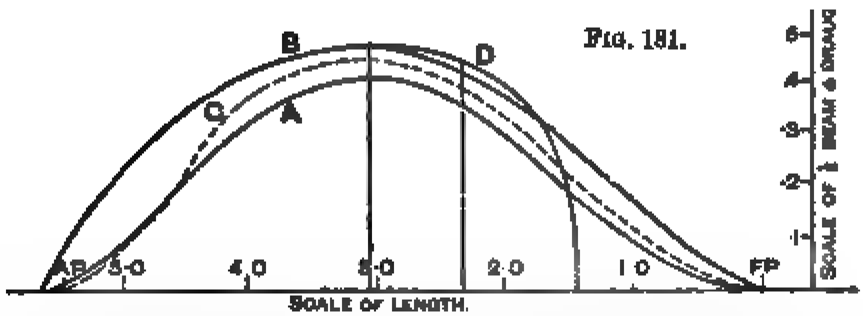


FIG. 181.

A, mean water-line, viz. curve of ½ areas ÷ mean draught. B, load water-line. C, water-line at half mean draught. D, greatest section.

The process of application of the 'skin friction correction' consists in deducting from the total C value for the model, the F value for model $=F_M$, and substituting that for ship $=F_S$; or, in other words, deducting the net value, $F_M - F_S$.

$$\text{Now } F_M - F_S = (O_M - O_S)\, SL^{-\cdot 175},$$

the value of O varying for each length as shown in the following table:—

TABLE OF VALUES OF O FOR VARIOUS LENGTHS.

Length in feet	Value of O	Length in feet	Value of O	Length in feet	Value of O	Length in feet	Value of O	Length in feet	Value of O
8	·14090	20	11470	60	·09380	160	·08219	450	·07312
9	·13734	25	·10976	70	·09164	180	·08108	500	·07219
10	·13409	30	·10590	80	·08987	200	·08012	550	·07132
12	·12853	35	·10282	90	·08840	250	·07814	600	·07051
14	12406	40	·10043	100	·08716	300	·07655		
16	·12036	45	·09839	120	·08511	350	·07525		
18	·11727	50	·09664	140	·08351	400	·07412		

* Correction curves for various length of ship. Ordinates downwards from 300 feet line to be added to, and upwards to be deducted from, the C readings of the constant curve.

The various constant values used are as follows:—

Let V = speed in knots; v = do. in hundreds of feet per minute.

R = resistance in tons in salt water; r = resistance in lbs. in fresh water.

D = displacement in tons in salt water; d = do. in lbs. in fresh water.

L = length in feet between perpendiculars.

S = wetted skin in square feet.

The speed constant $K = \frac{V}{D^{\frac{1}{6}}} \times \cdot 5834 = \frac{v}{d^{\frac{1}{6}}} \times 2\cdot 074.$

The resistance constant $C = \frac{R}{D^{\frac{2}{3}}V^{2}} \times 2938 = \frac{r}{d^{\frac{2}{3}} \times v^{2}} \times 232\cdot 5$

$$= \frac{EHP}{D^{\frac{2}{3}} \times V^{3}} \times 427\cdot 1.$$

The length speed constant $L_1 = \frac{V}{L^{\frac{1}{2}}} \times 1\cdot 0552 = \frac{v}{L^{\frac{1}{2}}} \times \cdot 01041.$

The length constant $M = \frac{L}{D^{\frac{1}{3}}} \times \cdot 3057 = \frac{L}{d^{\frac{1}{3}}} \times 3\cdot 966.$

The skin constant $S_1 = \frac{S}{D^{\frac{2}{3}}} \times \cdot 09346 = \frac{S}{d^{\frac{2}{3}}} \times 15\cdot 73.$

For given displacement, length of hull is proportional to value of M; given value of K implies given speed; and EHP at that speed is proportional to value of C.

FIG. 182.

Fig. 182 shows for one value of K the corresponding C values for various forms plotted as ordinates to a base scale of value of M; each such diagram, if interpreted by appropriate scales, is in effect a diagram showing EHP for given speed, for all the forms reduced to a common displacement, plotted to length of hull.

Corresponding Speeds.

Froude's Law of Comparison.—If the linear dimensions of a vessel be l times the dimensions of the model, and the resistance of the latter at speeds V_1, V_2, and V_3, &c., be R_1, R_2, R_3, &c., then at the corresponding speeds of the ship $V_1\sqrt{l}$, $V_2\sqrt{l}$, $V_3\sqrt{l}$, &c., the resistance of the ship will be R_1l^3, R_2l^3, R_3l^3. So that in order to compare the resistance of a model with that of the actual ship, the model must be run at the corresponding speed. If the model be constructed to a scale of $\frac{1}{4}$ inch to one foot, or $\frac{1}{48}$, the speed at which it must run, in order to compare with the ship at V knots, is $\frac{V}{\sqrt{48}}$.

The law is only correct when the frictional resistance is small compared with the residuary resistances, as the frictional resistance will follow a different law in the long and the short surfaces. If, however, the frictional resistance be calculated and deducted from the total resistance of the model, the law of comparison can then be used for the residuary resistances, and the calculated frictional resistance of the ship added to the result.

Also since the resistance varies as the cube of the length, and the speed as the square root of the length, the effective horse-power will vary as the (length) $\frac{7}{2}$.

This law can be used to compare full-sized vessels of similar shape but of different dimensions, and the correction for frictional resistance can generally be neglected. If the efficiency of the engines be the same for the two vessels, their I.H.P.'s can be considered proportional to their effective horse-power, which vary as the (ratio of their linear dimensions) $\frac{7}{2}$ when run at corresponding speeds.

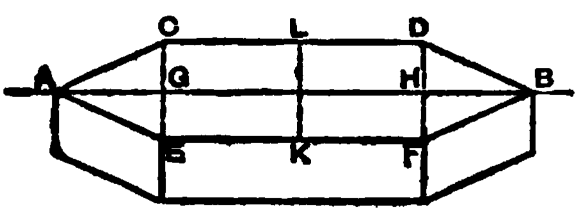
Kirk's Method of Analysing the Forms of Ships and Determining the Length and Angle of Entrance.

(*Transactions of Institution of Naval Architects.*)

A block model is constructed, having the same length and mean draught of water as the ship (see fig. 183). The main breadth KL is not equal to that of ship, but must be determined by dividing the area of midship section by the mean draught.

$$KL = \frac{\text{area of midship section}}{\text{mean draught}}.$$

Fig. 183.



The length of entrance HB and run AG are taken to be the same, so that by obtaining one the two are obtained.

Displacement = GB × area of midship section;

$$\therefore GB = \frac{\text{displacement}}{\text{area of midship section}}.$$

Length of entrance HB, or run AG = AB − GB;

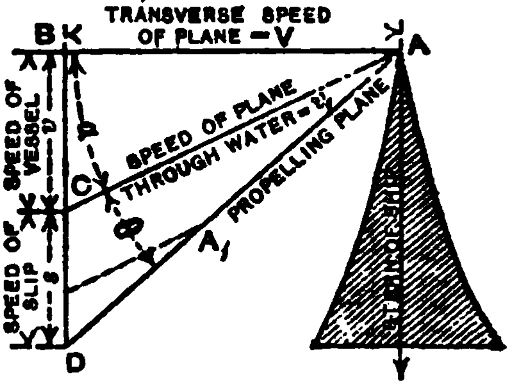
∴ length of entrance HB, or run AG

Elementary Relation between Pitch, Slip, and Propulsive Efficiency of the Screw Propeller. (W. Froude, M.I.N.A.)

(Taken from *Transactions of the Institution of Naval Architects*, 1878.)

Let A = Area of propelling plane = AA_1 in fig. 184.
V = transverse speed of propelling plane.
v = speed of ship.
v_1 = speed of path of plane relatively to the water.
A = virtual pitch angle.
θ = slip angle, or angle of plane relatively to its path.
ϕ = actual pitch angle $= a + \theta$.
P = normal pressure on the plane area moving through water with a speed v.
p = coefficient of pressure in lbs. per sq. ft. = 1·7 about.
f = coefficient of skin friction in lbs. per sq. ft.
= ·008 (being ·004 for each surface).
K = $\dfrac{f}{p}$ = ·0047 approximately.
F = skin friction on plane moving edgeways through water.
R = net force available for propulsion = ship's resistance.
U_e = effective work employed in overcoming ship's resistance with ship's actual speed.
U_g = gross work
S = speed of ship; slip ratio $= \dfrac{s}{s+v}$.

Fig. 184.



Areas are in sq. feet, pressures in lbs., speeds in feet per second, and angles in circular measure.

$$P = pAv^2 \sin\theta = pAV^2 \sec^2 a \sin\theta.$$
$$F = fAv^2 = fAV^2 \sec^2 a.$$
$$R = P\cos(a+\theta) - F\sin a.$$
$$U_e = Rv = RV\tan a = pAV^3 \sec^2 a \tan a \{\cos(a+\theta)\sin\theta - K\sin a\},$$
$$= pAv^3 \operatorname{cosec}^2 a \{\cos(a+\theta)\sin\theta - K\sin a\}.$$
$$U_g = pAV^3 \sec^2 a\{\sin(a+\theta)\sin\theta + K\cos a\}.$$
$$= pAv^3 \operatorname{cosec}^2 a \cot a \{\sin(a+\theta)\sin\theta + K\cos a\}$$
$$= Rv\cot a \frac{\sin(a+\theta)\sin\theta + K\cos a}{\cos(a+\theta)\sin\theta - K\sin a}.$$

$$E = \frac{U_e}{U_g} = \tan a \frac{\cos(a+\theta)\sin\theta - K\sin a}{\sin(a+\theta)\sin\theta - K\cos a}.$$

To determine the complete maximum efficiency make

$$E^* = 1 - 4\sqrt{K} + 8K - 8K\sqrt{K} = \cdot 77.$$

So that if we adopt the most probable values of p and f, and assume the propelling plane to be placed at the most effective pitch angle, and to operate with the most effective slip, 77 per cent. of the work delivered to the plane is the utmost that can be realised in propulsive effect.

$$A^* = \frac{R}{p\,v^2 \operatorname{cosec}^2 a\{\cos(a+\theta)\sin\theta - K\sin a\}}.$$

Graphic Description (see fig. 184).—The ship's wake is disregarded and the action is supposed to take place in undisturbed water. By the forward motion of the ship, the motion of a plane which is purely transverse as regards the ship becomes obliquely forward as regards the water, and the directions and magnitudes of the several elementary motions involved and the attitude of the plane in relation to them are shown.

The area of blade which will drive a ship with a given slip ratio is directly as the ship's resistance, and inversely as the square of the speed of the ship. And since at moderate speeds a ship's resistance may be taken as proportional to the square of her speed, the same area of propeller will at all moderate speeds drive a given ship with the same slip ratio; and areas directly as the squares of the respective dimensions of two similar ships will drive each ship with the same slip ratio, since at such speeds for similar but differently dimensioned well-formed ships the area of wetted surface in each measures its resistance.

At the higher speeds, which introduce other elements of resistance, the slip ratio will become greater with the given propelling area.

Maximum efficiency is not produced by extending the area of propelling plane so as to minimise slip; on the other hand, the slip angle which gives maximum efficiency is moderate. The value of θ which gives the maximum efficiency is the same whatever be the value of $(a+\theta)$ the pitch angle. To make the efficiency a maximum the slip angle must be directly as the square root of the coefficient of surface friction, and inversely as the square root of the coefficient of normal pressure; the value of $\theta = \sqrt{\frac{f}{p}}$.

To produce the maximum efficiency the propelling plane ought to stand at an angle of 45° with the line of the ship's motion.

If the slip angle exceed that which gives maximum efficiency, the pitch angle must also be increased; if the excess be small, the pitch angle must be increased by the same amount; if the excess be large, the increment of the pitch angle must be still greater.

The slip angle of maximum efficiency gives a slip ratio of about 12½ per cent., and the maximum efficiency is about 77 per cent.

A very much longer pitch than has been commonly adopted is favourable to efficiency. A large amount of slip is no proof of waste of power.

* Note in these cases the actual pitch angle $=(a+\theta)$ for maximum efficiency has been taken at 45° and θ as $=\sqrt{K} = \cdot 0047$ approximately. To determine the maximum efficiency for A, substitute $(a+\theta) = 45°$ $a = (45° - \theta)$ and $\theta = \sqrt{K}$, we get

$$A = \frac{R}{v^2}\left(\frac{1}{\sqrt{K}} - 1 - 2\sqrt{K}\right) = \frac{R}{v^2} \times 8\cdot 9.$$

RATIO OF EFFECTIVE TO INDICATED HORSE-POWER. (*Froude.*)

Indicated Thrust.

I = indicated thrust.
M = mean piston-pressure.
T = total piston-travel per revolution.
P = pitch of propeller.
N = number of revolutions.
IHP = indicated horse-power.

$$I = \frac{M \times T}{P} = \frac{33000 \times IHP}{P \times N}.$$

Indicated thrust is resolved into the following six elements:—

No. 1. The ship's nett resistance, or useful thrust.

No. 2. Augment of resistance due to negative pressure created about the ship's stern by the action of the screw. This is nearly proportional to the useful thrust.

No. 3. Water friction of screw. This is also nearly proportional to the useful thrust.

No. 4. Constant friction, or friction of engine without external load. This may also be taken as nearly proportional to the useful thrust.

No. 5. Friction due to external load. This may be taken as constant at all speeds.

No. 6. Air-pump and feed-pump resistance. This may be taken as nearly proportional to the square of the number of revolutions.

The above six elements are force factors, and when multiplied by $\dfrac{\text{the speed of ship in feet per minute}}{33000}$ constitute the ship's horse-power as fundamentally due to her progress.

Let EHP = effective horse-power—that is, the power due to the nett resistance of the ship.
SHP = ship's horse-power.
IHP = indicated horse-power.

Then the ship's horse-power due to the several elements is as follows:—

Ship's horse-power due to No. 1 = EHP.
" " " No. 2 = ·4 EHP.
" " " No. 3 = ·1 EHP.
" " " No. 4 = ·143 SHP.
" " " No. 5 = ·143 SHP.
" " " No. 6 = ·075 SHP.

Or in combination SHP = 1·5 EHP + ·361 SHP,
So that ·639 SHP = 1·5 EHP;

$$\text{or,}\quad \text{SHP} = \frac{1 \cdot 5}{\cdot 639}\ \text{EHP} = 2 \cdot 347\ \text{EHP}.$$

To this must be added—Slip = ·1 SHP,
making IHP = 1·1 SHP.

$$\text{Thus IHP} = 2 \cdot 582\ \text{EHP} = \frac{100}{38 \cdot 7}\ \text{EHP};$$

$$\text{or,}\quad \text{EHP} = \cdot 387\ \text{IHP}.$$

To convert the formula from one adapted to high speed only to one adapted to all speeds it is necessary to keep the term involving constant friction separate from the rest, for it represents simply the effect of a constant resistance operating with the existing speed of the engine.

In shaping the formula the coefficient 2·7, derived from rather broad experience, will be adhered to, instead of the coefficient 2·582, as the latter is built up from somewhat hypothetical data, assuming, however, that the constant friction is equal throughout to the one-seventh of the maximum load.

Of the 2·7 EHP which make up the IHP at the maximum speed V, one-seventh part, or ·385, is the part due to constant friction, leaving 2·315 as due to the other sources of expenditure of power. And to express the IHP due to constant friction at any other speed v, the coefficient must be altered in the direct ratio of the speed, so that the term becomes $\frac{v}{V} \times \cdot 385 \times \text{EHP}$ at designed maximum speed. Thus the formula for IHP at any speed v is as follows:—

$$\text{IHP} = 2 \cdot 315\ \text{EHP} + \cdot 385\ \frac{v}{V} \times (\text{EHP due to V});$$

or, if the useful is finally severed from the collateral expenditure of power, it stands thus:—

$$\text{IHP} = \text{EHP} + 1 \cdot 315\ \text{EHP} + \cdot 385\ \frac{v}{V} \times (\text{EHP due to V}).$$

To Determine the Initial and Constant Friction of a Marine Engine. (*Froude.*)

Construct a thrust curve (see fig. 185) by setting up ordinates y, y^1, y^2, y^3, &c., which represent to scale indicated thrusts taken at various speeds. The ordinates being set off at distances along the base line, commencing from the origin, so as to represent to scale the various speeds at which the thrust was taken, a curve bent through the ends of the ordinates will form part of a thrust curve. Let p be the lowest point found for the curve; at the point p draw the tangent pp'; draw the vertical at h so as to cut the space Oy into segments, making Oy = 1·87 Oh; draw a line

parallel to the base through the point c, where the vertical A cuts the tangent pp': the vertical height D between the parallel line and the base will represent the constant friction of the engine, and it will also be the height of the vertex of the thrust curve at the origin of the speed scale, which can thus be completed from the point p.

FIG. 185.

Note.—The heights of the ordinates above the line of constant friction are proportional to the ship's true resistance.

SPEED TRIALS.

MEASURED MILE.

To determine the true mean speed of a vessel when the runs are taken on the measured mile, half the number of runs being taken with the tide and half against the tide.

RULE.—Find the means of consecutive speeds continually found until only one remains.

Example.

Runs	Knots	1st Means	2nd Means	3rd Means	4th Means	Mean of Means
1st	15·4	12·75	12·475	12·45	12·425	12·396875 True mean speed.
2nd	10·1	12·20	12·425	12·40	12·36875	
3rd	14·3	12·65	12·375	12·3375		
4th	11·0	12·10	12·300			
5th	13·2	12·50	4 | 49·575			
6th	11·8		12·39375			
	6 | 75·8		Ordinary mean of second means.			
	12·633 Ordinary mean speed.					

Note.—The ordinary mean of second means is generally taken as sufficiently accurate.

SPEED OF THE CURRENT.

To find the speeds of the current in the line of the ship's course during her speed trials.

RULE.—Find the differences between the real speed of the ship and her observed speeds on the mile during the several runs.

Example.

Runs	Observed Speed	Real Speed	Differences	
1st	15·4	12·397	3·003	Knots with the ship
2nd	10·1	12·397	2·297	„ against „
3rd	14·3	12·397	1·903	„ with „
4th	11·0	12·397	1·397	„ against „
5th	13·2	12·397	·803	„ with „
6th	11·8	12·367	·597	„ against „

Sea Trials.

To determine the true mean speed of a vessel when the distance run is great.

Rule 1st.—Calculate the apparent speed of each run as usual, by dividing the distance by the time, and group them in sets of three; for example, 1, 2, 3; 2, 3, 4; 3, 4, 5; &c.

2nd.—Each set of three is to be treated as follows:—Find the two intervals of time between the middle instants of the first and second, and of the second and third runs of the set; reduce those intervals to the corresponding angular intervals by the following proportion:—

As $12^h\ 24^m$ (the duration of a tide) : is to a given interval of time :: so is 360° : to the corresponding angular interval.

3rd.—Multiply the *first* apparent speed by the co-secant of the *first* angular interval, the *second* apparent speed by the sum of the co-tangents of the *two* angular intervals, the *third* apparent speed by the co-secant of the *second* angular interval.

4th.—Add together the products and divide their sum by the sum of the before-mentioned multipliers; the quotient will be a speed from which tidal effects have been eliminated.

5th.—Add together the velocities deduced from the sets of three runs, and divide by their number for a final mean.

Note.—When an interval elapses of more than a quarter of a tide, or $3^h\ 6^m$, between the middle instants of the two runs of a set, certain multipliers and products must be *subtracted.*

The following example will determine whether these certain multipliers are to be taken as positive or negative.

Example.

Time.	Angles.	Co-secants.	Co-tangents.
Between $0^h\ 0^m$ and $3^h\ 6^m$	Between 0° and 90°	Positive	Positive.
Between $3^h\ 6^m$ and $6^h\ 12^m$	Between 90° and 180°	Positive	Negative.
Between $6^h\ 12^m$ and $9^h\ 18^m$	Between 180° and 270°	Negative	Positive.
Between $9^h\ 18^m$ and $12^h\ 24^m$	Between 270° and 360°	Negative	Negative.

TIME AND KNOT TABLE.

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.
0	60·000	30·000	20·000	15·000	12·000	10·000	8·571	7·500	6·667	6·000	5·455	5·000	4·615	4·286
1	59·016	29·752	19·890	14·938	11·960	9·972	8·551	7·484	6·654	5·990	5·446	4·993	4·609	4·281
2	58·064	29·508	19·780	14·876	11·921	9·945	8·531	7·469	6·642	5·980	5·438	4·986	4·604	4·275
3	57·143	29·268	19·672	14·815	11·881	9·917	8·511	7·453	6·630	5·970	5·430	4·979	4·598	4·270
4	56·250	29·032	19·565	14·754	11·842	9·890	8·491	7·438	6·618	5·960	5·422	4·972	4·592	4·265
5	55·384	28·800	19·459	14·694	11·803	9·863	8·471	7·423	6·606	5·950	5·414	4·965	4·586	4·260
6	54·545	28·571	19·355	14·634	11·765	9·836	8·451	7·407	6·593	5·941	5·405	4·959	4·580	4·255
7	53·731	28·346	19·251	14·575	11·726	9·809	8·431	7·392	6·581	5·931	5·397	4·952	4·574	4·250
8	52·941	28·125	19·149	14·516	11·688	9·783	8·411	7·377	6·569	5·921	5·389	4·945	4·568	4·245
9	52·174	27·907	19·048	14·458	11·650	9·756	8·392	7·362	6·557	5·911	5·381	4·938	4·563	4·240
10	51·428	27·692	18·947	14·400	11·613	9·730	8·372	7·347	6·545	5·902	5·373	4·931	4·557	4·235
11	50·704	27·481	18·848	14·343	11·576	9·704	8·353	7·332	6·534	5·892	5·365	4·925	4·551	4·230
12	50·000	27·273	18·750	14·286	11·538	9·677	8·333	7·317	6·522	5·882	5·357	4·918	4·545	4·225
13	49·315	27·068	18·653	14·229	11·502	9·651	8·314	7·302	6·510	5·873	5·349	4·911	4·540	4·220
14	48·648	26·866	18·557	14·173	11·465	9·626	8·295	7·287	6·498	5·863	5·341	4·905	4·534	4·215
15	48·000	26·667	18·461	14·118	11·429	9·600	8·276	7·273	6·486	5·854	5·333	4·898	4·528	4·210
16	47·368	26·471	18·367	14·062	11·392	9·574	8·257	7·258	6·475	5·844	5·325	4·891	4·523	4·206
17	46·753	26·277	18·274	14·008	11·356	9·549	8·238	7·243	6·463	5·835	5·318	4·885	4·517	4·201
18	46·154	26·087	18·182	13·953	11·321	9·524	8·219	7·229	6·452	5·825	5·310	4·878	4·511	4·196
19	45·570	25·899	18·090	13·900	11·285	9·499	8·200	7·214	6·440	5·816	5·302	4·871	4·506	4·191
Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.

TIME AND KNOT TABLE (continued).

The number in this table the time in which a vessel passes over the measured knot is rate in knots per hour.

Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.
20	45·000	25·714	18·000	13·846	11·250	9·474	8·182	7·200	6·429	5·806	5·294	4·865	4·500	4·186
21	44·444	25·532	17·910	13·793	11·215	9·449	8·163	7·186	6·417	5·797	5·286	4·858	4·494	4·181
22	43·902	25·352	17·822	13·740	11·180	9·424	8·145	7·171	6·406	5·788	5·279	4·852	4·489	4·176
23	43·373	25·175	17·734	13·688	11·146	9·399	8·126	7·157	6·394	5·778	5·271	4·845	4·483	4·171
24	42·857	25·000	17·647	13·636	11·111	9·375	8·108	7·143	6·383	5·769	5·263	4·839	4·478	4·167
25	42·353	24·828	17·561	13·585	11·077	9·351	8·090	7·129	6·372	5·760	5·255	4·832	4·472	4·162
26	41·860	24·658	17·476	13·534	11·043	9·326	8·072	7·115	6·360	5·751	5·248	4·826	4·466	4·157
27	41·379	24·490	17·391	13·483	11·009	9·302	8·054	7·101	6·349	5·742	5·240	4·819	4·461	4·152
28	40·909	24·324	17·308	13·433	10·976	9·278	8·036	7·087	6·338	5·732	5·233	4·813	4·455	4·147
29	40·450	24·161	17·225	13·383	10·942	9·254	8·018	7·073	6·327	5·723	5·225	4·806	4·450	4·143
30	40·000	24·000	17·143	13·333	10·909	9·231	8·000	7·059	6·316	5·714	5·217	4·800	4·444	4·138
31	39·561	23·841	17·062	13·284	10·876	9·207	7·982	7·045	6·305	5·705	5·210	4·794	4·439	4·133
32	39·130	23·684	16·981	13·235	10·843	9·184	7·965	7·031	6·294	5·696	5·202	4·787	4·433	4·128
33	38·710	23·529	16·901	13·187	10·811	9·160	7·947	7·018	6·283	5·687	5·195	4·781	4·428	4·124
34	38·298	23·377	16·822	13·139	10·778	9·137	7·930	7·004	6·272	5·678	5·187	4·774	4·423	4·119
35	37·895	23·226	16·744	13·091	10·746	9·114	7·912	6·990	6·261	5·669	5·180	4·768	4·417	4·114
36	37·500	23·077	16·667	13·043	10·714	9·091	7·895	6·977	6·250	5·660	5·172	4·762	4·412	4·110
37	37·113	22·930	16·590	12·996	10·682	9·068	7·877	6·963	6·239	5·651	5·165	4·756	4·406	4·105
38	36·735	22·785	16·514	12·950	10·651	9·045	7·860	6·950	6·228	5·643	5·158	4·749	4·401	4·100
39	36·364	22·642	16·438	12·903	10·619	9·023	7·843	6·936	6·218	5·634	5·150	4·743	4·396	4·096
Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.

TIME AND KNOT TABLE (concluded)

The number in this table corresponding to the time in which a vessel passes over the measured knot is her rate in knots per hour.

Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.
40	36·000	22·500	16·364	12·857	10·588	9·000	7·826	6·923	6·207	5·625	5·143	4·737	4·390	4·091
41	35·644	22·360	16·290	12·811	10·557	8·978	7·809	6·910	6·196	5·616	5·136	4·731	4·385	4·086
42	35·294	22·222	16·216	12·766	10·526	8·955	7·792	6·897	6·186	5·607	5·128	4·724	4·379	4·082
43	34·951	22·086	16·143	12·721	10·496	8·933	7·775	6·883	6·175	5·599	5·121	4·718	4·374	4·077
44	34·615	21·951	16·071	12·676	10·465	8·911	7·759	6·870	6·164	5·590	5·114	4·712	4·369	4·072
45	34·286	21·818	16·000	12·632	10·435	8·889	7·742	6·857	6·154	5·581	5·106	4·706	4·364	4·068
46	33·962	21·687	15·929	12·587	10·405	8·867	7·725	6·844	6·143	5·573	5·099	4·700	4·358	4·063
47	33·644	21·557	15·859	12·544	10·375	8·845	7·709	6·831	6·133	5·564	5·092	4·693	4·353	4·059
48	33·333	21·429	15·789	12·500	10·345	8·824	7·692	6·818	6·122	5·556	5·085	4·687	4·348	4·054
49	33·028	21·302	15·721	12·457	10·315	8·802	7·676	6·805	6·112	5·547	5·078	4·681	4·343	4·049
50	32·727	21·176	15·652	12·414	10·286	8·780	7·660	6·792	6·102	5·538	5·070	4·675	4·337	4·045
51	32·432	21·053	15·584	12·371	10·256	8·759	7·643	6·780	6·091	5·530	5·063	4·669	4·332	4·040
52	32·143	20·930	15·517	12·329	10·227	8·738	7·627	6·767	6·081	5·521	5·056	4·663	4·327	4·035
53	31·858	20·809	15·451	12·287	10·198	8·717	7·611	6·754	6·071	5·513	5·049	4·657	4·322	4·031
54	31·579	20·690	15·385	12·245	10·169	8·696	7·595	6·742	6·061	5·505	5·042	4·651	4·316	4·027
55	31·304	20·571	15·319	12·203	10·141	8·675	7·579	6·729	6·050	5·496	5·035	4·645	4·311	4·022
56	31·034	20·455	15·254	12·162	10·112	8·654	7·563	6·716	6·040	5·488	5·028	4·639	4·306	4·018
57	30·769	20·339	15·190	12·121	10·084	8·633	7·547	6·704	6·030	5·479	5·021	4·633	4·301	4·013
58	30·508	20·225	15·126	12·081	10·056	8·612	7·531	6·691	6·020	5·471	5·014	4·627	4·296	4·009
59	30·252	20·112	15·063	12·040	10·028	8·592	7·516	6·679	6·010	5·463	5·007	4·621	4·291	4·004
Secs.	1 min.	2 min.	3 min.	4 min.	5 min.	6 min.	7 min.	8 min.	9 min.	10 min.	11 min.	12 min.	13 min.	14 min.

TABLE OF COMPARISON OF ADMIRALTY KNOTS AND STATUTE MILES.

Knots	Miles	Knots	Miles	Knots	Miles	Knots	Miles	Knots	Miles
1·00	1·1515	6·00	6·9091	11·00	12·6667	16·00	18·4242	21·00	24·1818
1·25	1·4394	6·25	7·1970	11·25	12·9545	16·25	18·7121	21·25	24·4697
1·50	1·7273	6·50	7·4848	11·50	13·2424	16·50	19·0000	21·50	24·7576
1·75	2·0152	6·75	7·7727	11·75	13·5303	16·75	19·2879	21·75	25·0455
2·00	2·3030	7·00	8·0606	12·00	13·8182	17·00	19·5758	22·00	25·3333
2·25	2·5909	7·25	8·3485	12·25	14·1061	17·25	19·8636	22·25	25·6212
2·50	2·8788	7·50	8·6364	12·50	14·3939	17·50	20·1515	22·50	25·9091
2·75	3·1667	7·75	8·9242	12·75	14·6818	17·75	20·4394	22·75	26·1970
3·00	3·4545	8·00	9·2121	13·00	14·9697	18·00	20·7273	23·00	26·4848
3·25	3·7424	8·25	9·5000	13·25	15·2576	18·25	21·0152	23·25	26·7727
3·50	4·0303	8·50	9·7879	13·50	15·5455	18·50	21·3030	23·50	27·0606
3·75	4·3182	8·75	10·0758	13·75	15·8333	18·75	21·5909	23·75	27·3485
4·00	4·6061	9·00	10·3636	14·00	16·1212	19·00	21·8788	24·00	27·6364
4·25	4·8939	9·25	10·6515	14·25	16·4091	19·25	22·1667	24·25	27·9242
4·50	5·1818	9·50	10·9394	14·50	16·6970	19·50	22·4545	24·50	28·2121
4·75	5·4697	9·75	11·2273	14·75	16·9848	19·75	22·7424	24·75	28·5000
5·00	5·7576	10·00	11·5152	15·00	17·2727	20·00	23·0303	25·00	28·7879
5·25	6·0455	10·25	11·8030	15·25	17·5606	20·25	23·3182	25·25	29·0758
5·50	6·3333	10·50	12·0909	15·50	17·8485	20·50	23·6061	25·50	29·3636
5·75	6·6212	10·75	12·3788	15·75	18·1364	20·75	23·8939	25·75	29·6515

Miles	Knots	Miles	Knots	Miles	Knots	Miles	Knots	Miles	Knots
1·00	·8684	6·00	5·2105	11·00	9·5526	16·00	13·8947	21·00	18·2368
1·25	1·0855	6·25	5·4276	11·25	9·7697	16·25	14·1118	21·25	18·4539
1·50	1·3026	6·50	5·6447	11·50	9·9868	16·50	14·3289	21·50	18·6711
1·75	1·5197	6·75	5·8618	11·75	10·2039	16·75	14·5461	21·75	18·8882
2·00	1·7368	7·00	6·0789	12·00	10·4211	17·00	14·7632	22·00	19·1053
2·25	1·9539	7·25	6·2961	12·25	10·6382	17·25	14·9803	22·25	19·3224
2·50	2·1711	7·50	6·5132	12·50	10·8553	17·50	15·1974	22·50	19·5395
2·75	2·3882	7·75	6·7303	12·75	11·0724	17·75	15·4145	22·75	19·7566
3·00	2·6053	8·00	6·9474	13·00	11·2895	18·00	15·6316	23·00	19·9737
3·25	2·8224	8·25	7·1645	13·25	11·5066	18·25	15·8487	23·25	20·1908
3·50	3·0395	8·50	7·3816	13·50	11·7237	18·50	16·0658	23·50	20·4079
3·75	3·2566	8·75	7·5987	13·75	11·9408	18·75	16·2829	23·75	20·6250
4·00	3·4737	9·00	7·8158	14·00	12·1579	19·00	16·5000	24·00	20·8421
4·25	3·6908	9·25	8·0329	14·25	12·3750	19·25	16·7171	24·25	21·0592
4·50	3·9079	9·50	8·2500	14·50	12·5921	19·50	16·9342	24·50	21·2763
4·75	4·1250	9·75	8·4671	14·75	12·8092	19·75	17·1513	24·75	21·4934
5·00	4·3421	10·00	8·6842	15·00	13·0263	20·00	17·3684	25·00	21·7105
5·25	4·5592	10·25	8·9013	15·25	13·2434	20·25	17·5855	25·25	21·9276
5·50	4·7763	10·50	9·1184	15·50	13·4605	20·50	17·8026	25·50	22·1447
5·75	4·9934	10·75	9·3355	15·75	13·6776	20·75	18·0197	25·75	22·3618

N.B. The Admiralty knot = 6,080 ft.; 1 statute mile = 5,280 ft.

TABLE OF KILOMETRES TO ADMIRALTY KNOTS AND ADMIRALTY KNOTS TO KILOMETRES.

Kilos.	Knots	Kilos.	Knots	Kilos.	Knots	Kilos.	Knots	Kilos.	Knots
1·0	·540	8·0	4·317	15·0	8·094	22·0	11·872	29·0	15·649
1·25	·675	8·25	4·452	15·25	8·229	22·25	12·006	29·25	15·784
1·5	·809	8·5	4·587	15·5	8·364	22·5	12·141	29·5	15·919
1·75	·944	8·75	4·722	15·75	8·499	22·75	12·276	29·75	16·054
2·0	1·079	9·0	4·857	16·0	8·634	23·0	12·411	30·0	16·188
2·25	1·214	9·25	4·991	16·25	8·769	23·25	12·546	30·25	16·323
2·5	1·349	9·5	5·126	16·5	8·904	23·5	12·681	30·5	16·458
2·75	1·484	9·75	5·261	16·75	9·039	23·75	12·816	30·75	16·593
3·0	1·619	10·0	5·396	17·0	9·173	24·0	12·951	31·0	16·728
3·25	1·754	10·25	5·531	17·25	9·308	24·25	13·086	31·25	16·863
3·5	1·889	10·5	5·666	17·5	9·443	24·5	13·221	31·5	16·998
3·75	2·024	10·75	5·801	17·75	9·578	24·75	13·356	31·75	17·133
4·0	2·158	11·0	5·936	18·0	9·713	25·0	13·490	32·0	17·268
4·25	2·293	11·25	6·071	18·25	9·848	25·25	13·625	32·25	17·403
4·5	2·428	11·5	6·206	18·5	9·983	25·5	13·760	32·5	17·538
4·75	2·563	11·75	6·340	18·75	10·118	25·75	13·895	32·75	17·672
5·0	2·698	12·0	6·475	19·0	10·253	26·0	14·030	33·0	17·807
5·25	2·833	12·25	6·610	19·25	10·388	26·25	14·165	33·25	17·942
5·5	2·968	12·5	6·745	19·5	10·523	26·5	14·300	33·5	18·077
5·75	3·103	12·75	6·880	19·75	10·657	26·75	14·435	33·75	18·212
6·0	3·238	13·0	7·015	20·0	10·792	27·0	14·570	34·0	18·347
6·25	3·373	13·25	7·150	20·25	10·927	27·25	14·705	34·25	18·482
6·5	3·508	13·5	7·285	20·5	11·062	27·5	14·839	34·5	18·617
6·75	3·642	13·75	7·420	20·75	11·197	27·75	14·974	34·75	18·752
7·0	3·777	14·0	7·555	21·0	11·332	28·0	15·109	35·00	18·887
7·25	3·912	14·25	7·690	21·25	11·467	28·25	15·244	35·25	19·021
7·5	4·047	14·5	7·824	21·5	11·602	28·5	15·379	35·5	19·156
7·75	4·182	14·75	7·959	21·75	11·737	28·75	15·514	35·75	19·291

Knots	Kilos.	Knots	Kilos.	Knots	Kilos.	Knots	Kilos.	Knots	Kilos.
1·0	1·853	4·75	8·803	8·5	15·752	12·25	22·701	16·0	29·651
1·25	2·316	5·0	9·266	8·75	16·215	12·5	23·165	16·25	30·114
1·5	2·780	5·25	9·729	9·0	16·679	12·75	23·628	16·5	30·577
1·75	3·243	5·5	10·192	9·25	17·142	13·0	24·091	16·75	31·041
2·0	3·706	5·75	10·656	9·5	17·605	13·25	24·554	17·0	31·504
2·25	4·170	6·0	11·119	9·75	18·068	13·5	25·018	17·25	31·967
2·5	4·633	6·25	11·582	10·0	18·532	13·75	25·481	17·5	32·430
2·75	5·096	6·5	12·046	10·25	18·995	14·0	25·944	17·75	32·894
3·0	5·560	6·75	12·509	10·5	19·458	14·25	26·408	18·0	33·357
3·25	6·023	7·0	12·972	10·75	19·922	14·5	26·871	18·25	33·820
3·5	6·486	7·25	13·435	11·0	20·385	14·75	27·334	18·5	34·284
3·75	6·949	7·5	13·899	11·25	20·848	15·0	27·798	18·75	34·747
4·0	7·413	7·75	14·362	11·5	21·311	15·25	28·261	19·0	35·210
4·25	7·876	8·0	14·825	11·75	21·775	15·5	28·724	19·25	35·673
4·5	8·339	8·25	15·289	12·0	22·238	15·75	29·187	19·5	36·137

SAILING.

Centre of Lateral Resistance.

The centre of lateral resistance is the centre of application of resistance of the water; and as this varies in position with the speed of the ship, &c., it is not determinate, but a point is generally taken at the centre of the immersed longitudinal vertical middle plane of the vessel as sufficiently accurate.

Centre of Effort.

The point in the longitudinal vertical middle plane of a vessel which is traversed by the resultant of the pressure of the wind on the sails is termed the centre of effort; its position varies according to the quantity of sail spread, &c., but its position is determined approximately for purposes connected with designing the sails, all plain sail only being taken—that is, the sails that are more commonly used, and which can be carried with safety in a fresh breeze (see table, p. 161). They are as follows:—

In square-rigged vessels: the fore and main courses, fore, main, and mizen topsails, fore, main, and mizen topgallant sails, driver, jib, and sometimes the fore topmast staysail.

In fore and aft rigged vessels: the main sail, fore sail, and sometimes the second or third jib.

In calculating the position of the centre of effort by the following rules the sails are taken braced right fore and aft.

To find the perpendicular height of the centre of effort above the centre of lateral resistance.

Rule.—Multiply the area of each sail by the height of its centre of gravity above the centre of lateral resistance; take the sum of those products (or moments) and divide it by the total area of sail: the quotient will be the required result.

To find the lateral position of the centre of effort relatively to the centre of lateral resistance.

Rule.—Multiply the area of each sail whose centre lies to one side of a vertical axis passing through the centre of lateral resistance by the perpendicular distance of its centre from that axis, and add the products (or moments) together.

Treat the other sails whose centres lie to the other side of the axis of moments in the same way as before, and add their products together.

The difference between the two sums divided by the total area of sail, will give the perpendicular distance of the centre of effort from the given axis.

Note.—The centre of effort will lie to that side which has the greatest moment of sail.

The following table shows the method in which the centre of effort is calculated.

TABLE SHOWING METHOD OF CALCULATING THE POSITION OF THE CENTRE OF EFFORT RELATIVELY TO THE CENTRE OF LATERAL RESISTANCE.

Name of Sail	Areas	Distances of Centre of Sails		Moments		Heights of Centre of Sails Above	Vertical Moments
		Before	Abaft	Before	Abaft		
Jib . . .	2040	138	—	281520	—	87·3	178092
Fore course .	4050	78	—	315900	—	56·0	226800
„ topsail .	4330	78	—	337740	—	109·5	474135
„ topgallant sail .	1500	78	—	117000	—	158·8	238200
Main course .	5488	—	12·5	—	68600	58·3	319950
„ topsail .	5440	—	14·0	—	76160	117·3	638112
„ topgallant sail .	1881	—	15·5	—	29155·5	172·0	323532
Driver . .	2831·5	—	100·5	—	284565·7	62·5	176968·7
Mizen topsail .	2645	—	78·0	—	206310	99·5	263177·5
„ topgallant sail .	902	—	79·5	—	71709	136·0	122672
	31107·5			1052160	736500·2		2961639·6

$$\left.\begin{array}{r}\text{Hght. of Centre of Effort above}\\ \text{Centre of Lateral Resistance}\end{array}\right\} = \frac{\text{moment } 2961639{\cdot}6}{\text{area} \quad 31107{\cdot}5} = 95{\cdot}3$$

$$\left.\begin{array}{r}\text{Dist. of Centre of Effort before}\\ \text{Centre of Lateral Resistance}\end{array}\right\} = \frac{\text{moments } 1052160 - 736500{\cdot}2}{\text{area} \quad 31107{\cdot}5} = 10{\cdot}1$$

ARDENCY.

Ardency is the tendency a ship has to fly up to the wind, thus showing that the position of her centre of effort is abaft the centre of lateral resistance.

SLACKNESS.

Slackness is the tendency a ship has to fall off from the wind, thus showing that the position of her centre of effort is before the centre of lateral resistance.

Relative Position of Centre of Effort and Centre of Lateral Resistance.

D = distance of centre of effort before centre of lateral resistance.

D_1 = distance of centre of effort above centre of lateral resistance.

L = length of load water-line.

A = area of load water-line.

d = distance of centre of buoyancy of ship below load water-line.

d_1 = distance of centre of lateral resistance abaft the middle of the load water-line.

d_2 = distance of centre of buoyancy before the middle of the load water-line.

$$D = \frac{L(\frac{3}{4}d_1 + d_2)}{10(d_1 + d_2)} \text{ for square-rigged vessels.}$$

$$D = \frac{L}{10(d_1 + d_2)} \text{ for cutter and fore and aft rigged vessels.}$$

$$D_1 = \frac{4A}{5d}.$$

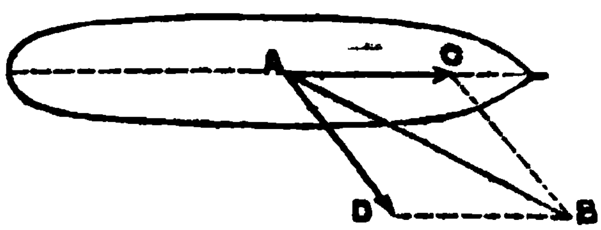
Note.—The centre of effort of the sails, to produce the best effect, must be higher or lower according as the ship is more or less full at the load water-line compared with the fulness of the body at the extremities below the water. Ships that are full at the load water-line and clean below at the extremities require the higher masts.

Real and Apparent Motion of the Wind.

By the real motion of the wind is meant its motion relatively to the earth, and by its apparent motion its motion relatively to the ship when she is sailing.

The apparent motion being the resultant of the real motion of the wind and of a motion equal and directly opposite to that of the ship.

Fig. 186.



In fig. 186 let AB represent in magnitude and direction the real motion of the wind, and AC the direction and velocity of the motion of the ship; through B draw BD parallel and equal to AC; join DA: then DA will represent in magnitude and direction the apparent motion of the wind.

In algebraical symbols let—

a = angle ADB made by the point from which the apparent wind blows with the course of the ship.

K = supplement of ABD, the corresponding angle for the real wind.

$r = \frac{AD}{DB}$ = ratio of velocity of apparent wind to that of the ship.

$r_1 = \frac{AB}{DB}$ = ratio of velocity of real wind to that of the ship.

$r = \{\sqrt{(r_1^2 - 1 + \cos^2 a)} + \cos a\}$.

When a is obtuse, $r = \{\sqrt{(r_1^2 - 1 + \cos^2 a)} - \cos a\}$.

$r = \sqrt{(1 + r_1^2 + 2r_1 \,.\, \cos K)}$.

When K is obtuse, $r = \sqrt{(1 + r_1^2 - 2r_1 \cos K)}$.

$r_1 = \sqrt{(1 + r^2 - 2r \,.\, \cos a)}$.

When a is obtuse, $r = \sqrt{(1 + r^2 + 2r \,.\, \cos a)}$.

$$\text{Sin } K = \frac{r}{r_1} \sin a. \qquad \text{Sin } a = \frac{r_1}{r} \sin K.$$

EFFECTIVE IMPULSE OF WIND.

D = direct impulse of wind on sails = area × pressure in lbs.

E = effective impulse of wind on sails in lbs.

C = component of effective impulse which produces leeway and tends to heel the ship over.

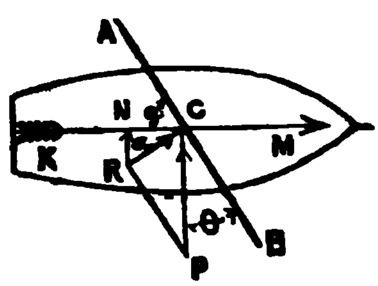
C_1 = component of effective impulse which moves the ship ahead.

θ = angle made by direction of apparent motion of wind with the plane of the sails (see fig. 187).

a = angle made by the plane of the sails with the ship's course (see fig. 187).

$$E = D \sin^2 \theta. \quad C = E \cos a. \quad C_1 = E \sin a.$$

FIG. 187.



In fig. 187 let PC represent in magnitude and direction the pressure of the apparent wind on the sail AB; through P draw PR parallel to AB; through C draw CR perpendicular to PR and cutting PR in R: then RC is the effective pressure of the wind on the sail AB, and RN perpendicular to KM is the component of RC which produces heel and leeway, while NC is the component of RC which propels the ship along.

TABLE OF DIRECT IMPULSE OF WINDS IN LBS. PER SQUARE FOOT, AND SAILS COMMONLY SET BY THE WIND.

Velocity in Knots per Hour	Impulse in lbs.	Name of Wind	Sails commonly set by the Wind
1	·0067	Light air	Courses, topsails, topgallant sails, royals, spanker, jib, flying jib, and all light sails.
2	·027		
3	·060		
4	·107	Light wind	
5	·167		
6	·240	Light breeze	
7	·327		
8	·427	Moderate breeze	
9	·540		
10	·667	Fresh breeze	Royals and flying jib taken in in a sea way to two reefs in the topsails.
11	·807		
12	·960		
13	1·13		
14	1·31		
15	1·50	Strong breeze	Single-reefed topsails and topgallant sails in much sea, two reefs in the topsails to taking in topgallant sails.
16	1·71		
17	1·93		
18	2·16		
19	2·41		
20	2·67		
22	3·23	Moderate gale	Double-reefed topsails to treble-reefed topsails, reefed spanker and jib.
24	3·84		
26	4·51	Fresh gale	Close-reefed topsails, reefed courses to taking in spanker, jib, fore and mizen topsails.
28	5·23		
30	6·00		
32	6·83	Strong gale	Reefed courses, close-reefed main topsail, fore staysail, mizen topsail to taking in the main sail.
34	7·71		
36	8·64		
38	9·63	Heavy gale	Close-reefed main topsail to storm staysails, or close-reefed main topsail only.
40	10·7		
45	13·5	Storm	
50	16·7		
60	24·0	Hurricane	
70	32·7		
80	42·7		
90	54·0		
100	66·7		

Impulse of Wind.

V = velocity of wind in knots per hour.
D = direct impulse in lbs. on one square foot.

$$D = \frac{V^2}{150} = V^2 \cdot 006667.$$

Speed of Similar Vessels under Sail.

V = velocity of ship. D = displacement of ship.
X = area of midship section. A = area of sails.

c and c_1 = constants depending upon form below water.

$$V = \sqrt{\frac{A}{cD^{\frac{2}{3}}}} = \sqrt{\frac{A}{c_1 X}} \qquad A = cD^{\frac{2}{3}}V^2 = c_1 V^2 X.$$

$$c = \frac{A}{D^{\frac{2}{3}}V^2} \qquad c_1 = \frac{A}{XV^2}.$$

Table of the Ratio of a Ship's Speed under Sail to Speed of Real Wind.

Ratio of Area of Sails to Augmented Surface	Relation between Course and Wind	Probable Ratio of Speed of Ship to Sp. of Real Wind
1	Course 5 points near wind . .	$\frac{1}{3}$
	Wind 2 points abaft beam . .	$\frac{1}{2}$
$1\frac{1}{2}$	Course 6 points near wind . .	$\frac{1}{2}$
	Wind abeam	$\frac{3}{5}$
	Wind astern	$\frac{1}{2}$
2	Course 5 points near wind . .	$\frac{1}{2}$
	Wind 2 points abaft beam . .	$\frac{2}{3}$
$2\frac{1}{2}$	Course about $6\frac{1}{2}$ points near wind	$\frac{2}{3}$
	Wind on quarter	$\frac{2}{3}$

Table of the Ratio of the Probable Speed of Vessels under Steam and Canvas to those under Steam.

Speed under canvas ÷ speed under steam	Probable speed under steam and canvas ÷ speed under steam	Speed under canvas ÷ speed under steam	Probable speed under steam and canvas ÷ speed under steam
·4	1·02	1·3	1·47
·5	1·04	1·4	1·55
·6	1·07	1·5	1·64
·7	1·10	1·6	1·72
·8	1·15	1·7	1·81
·9	1·20	1·8	1·90
1·0	1·26	1·9	1·99
1·1	1·33	2·0	2·08
1·2	1·40	—	—

HEELING MOMENT OF SAILS.

E = effective impulse of wind on sails in lbs. (see p. 160).

D = displacement of vessel in lbs.

C = height of centre of effort above centre of lateral resistance.

G = height metacentre above centre of gravity.

L = length of arm of righting couple at a given angle of heel.

M = heeling moment of sails.

a = angle made by plane of sails with course of ship (see fig. 187).

θ = angle of heel of vessel.

$$M = C \,.\, E \,.\, \cos a \,.\, \cos \theta.$$

The steady angle of heel of a vessel due to M will be that at which $M = D \,.\, G \,.\, \sin \theta$ (for small angles of heel),

$M = L \,.\, D$ (for any angle of heel).

In the two last formulæ the reduction in the effective heeling power of the wind due to the sails being inclined from the upright position has been neglected, but if necessary the diminution of the effective pressure of the wind may be taken to vary as the sine squared of the angle of incidence of the wind with the plane of the ship's sails, or as the cosine squared of the angle of heel.

Note.—In a general sense the moment of sail is usually understood to be the product of the area of all plain sail into the height of the centre of effort above the centre of lateral resistance, as the pressure of wind is generally taken as one pound on the square foot; and the product of the weight of the ship in lbs. into the height of the metacentre above the centre of gravity, divided by the moment of sail, is taken as a measure of her efficiency to resist inclination under canvas.

AREA OF SAIL.

To determine accurately the quantity of sail suitable for any vessel to carry, make the moment of sail equal to the moment of stability at a definite angle of heel; but the following rule may generally be taken as sufficiently approximate:—

A = quantity of sail suitable to a given vessel.

D = displacement of vessel in lbs.

M = height of metacentre above centre of gravity.

H = height of centre of effort above centre of lateral resistance.

θ = angle of heel in circular measure suitable to given vessel taken from the following table.

$$A = \frac{D \times M \times \theta}{H}$$

[illegible] OF ANGLE OF STEADY HEEL FOR DIFFERENT CLASSES OF VESSELS.

Class of Vessel	Angle of Heel	Circular Measure
[illegible] and large merchant ships	4°	·070
Corvettes	5°	·087
[illegible] and [illegible]	6°	·105
Yachts	6° to 9°	·105 to ·157

[illegible] OF THE AREA AND MOMENT OF SAILS OF SOME OF HER MAJESTY'S SCREW VESSELS.

	A	B	C	D	E	F ft.	F in.	G	H
[illegible]	[illegible]	[illegible]	3·11	[illegible]	23·33	26	10	1·517	3·088
[illegible]	[illegible]	[illegible]	3·15	[illegible]	26·1	24	8½	2·03	3·28
[illegible]	[illegible]	[illegible]	[illegible]	105·4	21·2	21	4	1·00	3·40
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18·9	24	0¾	1·38	2·69
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15·1	23	10½	1·42	2·80
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17·3	22	0	·66	3·012
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17·3	24	1½	·76	2·37
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30·0	26	8½	1·999	3·879
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26·6	16	6½	1·35	3·52
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51·7	25	5	2·15	6·01
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19·8	26	0	2·35	2·64
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19·3	24	10½	1·8	3·05
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37·9	25	8	1·89	4·61
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29·9	11	2¼	·95	4·21
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	35·4	26	5½	2·285	4·678

[illegible] square feet.

[illegible] of midship section at load [illegible]

[illegible] of displacement at load [illegible]

[illegible] lateral resistance divided [illegible] distance between the meta- [illegible]

[illegible] multiplied by the distance [illegible] centre of gravity, and the [illegible] of sail about the centre of [illegible]

Note.—This is a measure of the power of a ship to resist inclination under her canvas.

F = mean load-draught of water in feet and inches.

G = distance of centre of gravity below load water-line in feet.

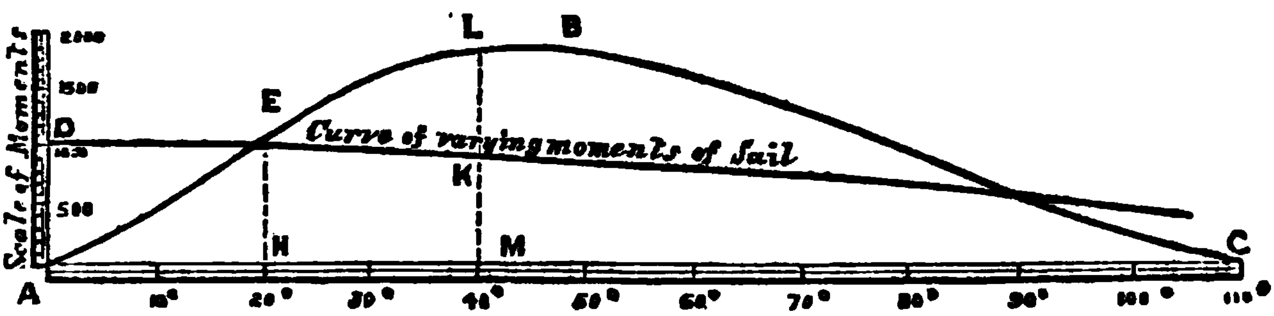
H = height of metacentre above centre of gravity in feet.

Effect of Gust of Wind on a Ship's Sails.

The effect of a sudden gust of wind upon a ship's sails is, as a rule, to heel her over to an extreme angle of heel of about twice the steady angle at which the same constant pressure of wind would keep her.

In fig. 188 let ABC be the ship's curve of statical stability, and DE her curve of varying moments of sail—that is, the ordinates which express the moment of sail at the different angles vary as the cosine² of the angle of heel.

FIG. 188.



If the wind is steadily applied the ship will remain inclined at a steady angle of heel of 20°, determined by dropping an ordinate at the point of intersection E of the two curves; but in the case of the same pressure of wind being suddenly applied she will heel over beyond the steady angle of heel, and she will oscillate for a time about that angle, the reason being that an amount of mechanical work has been done in heeling her over to 20°, which is represented by the area ADEH, whereas the work absorbed is only equal in area to AEH; hence mechanical work has been accumulated equal to the area AED. The ship will therefore continue to heel over till this work has been absorbed; this will occur at 40°, when the area EKL is equal to the area AED, or, in other words, when the area ALM—the dynamical stability at 40°— is equal to the area ADKM she will commence a return oscillation under the influence of a righting moment, represented by ML.

TABLE OF DISTANCES FROM CARLISLE BRIDGE TO ROCK-A-BILL LIGHT, AND FROM CARLISLE BRIDGE TO WICKLOW HEAD, IN NAUTICAL MILES.

	Carlisle Bridge	North Wall Light	Pool Beg Light	Bailey Light	Howth Harbour Light	Kingstown, E. Pier	Kish Light-vessel
Carlisle Bridge							
North Wall Light	1·17						
Pool Beg Light	3·97	2·80					
Bailey Light	7·77	6·60	3·80				
Howth Harbour Light	10·57	9·40	6·60	2·80			
Rock-a-Bill Light	22·77	21·60	18·80	15·00	13·20		
Kingstown, E. Pier	6·67	5·50	2·70	4·50	—		
Kish Light-vessel	13·32	12·15	9·35	5·00	—	6·65	
Wicklow Head	34·32	33·15	30·35	—	—	27·65	
Wicklow Head, 2 lights in one, distance 1¼ mile	28·17	27·00	24·20	23·92	—	21·50	21·00

The distance from Kingstown (E. Pier) to Holyhead is 56 knots, or 64·48 statute miles.
Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

Table of Distances from Cumberland Basin down the Bristol Channel in Nautical Miles.

	Cumberland Basin	Lamplighter Slip	King Road, Black Buoy	Portishead Point	Lightship on Welsh and English Grounds	Lightship on Flat Holmes	Black and White Striped Buoy at Breaksea Point	Nash Point, bearing 1 mile N. by E.	West Helwick Sand Light-vessel
Lamplighter Slip	4·0								
King Road, Black Buoy	6·4	2·4							
Portishead Point	8·4	4·4	2·0						
Lightship on Welsh and English Grounds	16·0	12·0	9·6	7·6					
Lightship on Flat Holmes	22·8	18·8	16·4	14·4	6·8				
Foreland Point	49·6	45·6	43·2	41·2	33·6				
Ilfracombe	62·0	58·0	55·6	53·6	46·0				
Black and White Striped Buoy at Breaksea Pt.	33·9	29·9	27·5	25·5	17·9	11·1			
Nash Point, bearing 1 mile N. by E.	39·5	35·5	33·1	31·1	23·5	16·7	5·6		
West Helwick Sand Light-vessel	71·7	67·7	65·3	63·3	55·7	48·9	37·8	32·2	
St. Ann's Head Lighthouse	103·7	99·7	97·3	95·3	87·7	80·9	69·8	64·2	32·0

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES FROM CARLISLE BRIDGE TO ROCK-A-BILL LIGHT, AND FROM CARLISLE BRIDGE TO WICKLOW HEAD, IN NAUTICAL MILES.

Carlisle Bridge	Carlisle Bridge	North Wall Light	Pool Beg Light	Bailey Light	Howth Harbour Light	Kingstown, E. Pier	Kish Light-vessel
North Wall Light	1·17						
Pool Beg Light	3·97	2·80					
Bailey Light	7·77	6·60	3·80				
Howth Harbour Light	10·57	9·40	6·60	2·80			
Rock-a-Bill Light	22·77	21·60	18·80	15·00	13·20		
Kingstown, E. Pier	6·67	5·50	2·70	4·50	—		
Kish Light-vessel	13·32	12·15	9·35	5·00	—	6·65	
Wicklow Head	34·32	33·15	30·35	—	—	27·65	
Wicklow Head, 2 lights in one, distance 1½ mile	28·17	27·00	24·20	23·92	—	21·50	21·00

The distance from Kingstown (E. Pier) to Holyhead is 56 knots, or 64·48 statute miles.
Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

Table of Distances from Cumberland Basin down the Bristol Channel in Nautical Miles.

	Cumberland Basin	Lamplighter Slip	King Road, Black Buoy	Portishead Point	Lightship on Welsh and English Grounds	Lightship on Flat Holmes	Black and White Striped Buoy at Break-sea Point	Nash Point, bearing 1 mile N. by E.	West Helwick Sand Light-vessel
Lamplighter Slip	4·0								
King Road, Black Buoy	6·4	2·4							
Portishead Point	8·4	4·4	2·0						
Lightship on Welsh and English Grounds	16·0	12·0	9·6	7·6					
Lightship on Flat Holmes	22·8	18·8	16·4	14·4	6·8				
Foreland Point	49·6	45·6	43·2	41·2	33·6				
Ilfracombe	62·0	58·0	55·6	53·6	46·0				
Black and White Striped Buoy at Breaksea Pt.	33·9	29·9	27·5	25·5	17·9	11·1			
Nash Point, bearing 1 mile N. by E.	39·5	35·5	33·1	31·1	23·5	16·7	5·6		
West Helwick Sand Light-vessel	71·7	67·7	65·3	63·3	55·7	48·9	37·8	32·2	
St. Ann's Head Lighthouse	103·7	99·7	97·3	95·3	87·7	80·9	69·8	64·2	32·0

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

		Roc	Crosby	Formby Lig	Bell Beacon	North-west Lightsh	North Toe, Great Orme	Point Lynas	Skerries
Rock Lighthouse, No. 5, Red Buoy	4·40								
Crosby Lightship	9·20	4·80							
Formby Lightship	11·80	7·40	2·60						
Bell Beacon	14·10	9·70	4·90	2 30					
North-west Lightship	18·72	14·32	9·52	6·92	4·62				
North Toe, Great Orme's Head	40·72	36·32	31·52	29·92	26·62	22·00			
Point Lynas	56·52	52·12	47·32	44·72	22·42	37·80	15·80		
Point Lynas	55·22	50·82	46·02	43·42	41·12	36·50	—		
Skerries	67·22	62·82	58·02	55·42	53·12	48·50	—	12·00	
Holyhead Breakwater Light	72·82	68·42	63·[illegible]	61·02	58·72	54·10	—	17·[illegible]	5·60

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES DOWN THE CENTRE OF THE RIVER TYNE IN NAUTICAL MILES.

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

	Tyne Bridge	Tyne Main Shipping Spout	Friar's Goose Point	St. Anthony's Point	Bill Point	Hebburn Quay Road at Leslie's Building Yard	Wallsend Ironworks	Howdon Landing, opposite Palmer's Iron Ship-building Yard	Northumberland Dock Entrance	Jarrow Dock Entrance, opposite side	Whitehill Point, North side	Mill Dam Landing-place, South Shields	New Quay Landing-place, North Shields	Low Lighthouse, North Shields
Tyne Main Shipping Spout	1·09													
Friar's Goose Point	1·44	·35												
St. Anthony's Point	2·20	1·11	·76											
Bill Point	2·70	1·61	1·26	·50										
Hebburn Quay Road at Leslie's Building Yard	4·02	2·93	2·58	1·82	1·32									
Wallsend Ironworks	4·50	3·41	3·06	2·30	1·80	·48								
Howdon Landing, opposite Palmer's Iron Ship-building Yard	5·43	4·34	3·99	3·23	2·73	1·41	·93							
Northumberland Dock Entrance	6·08	4·99	4·64	3·88	3·38	2·06	1·58	·65						
Jarrow Dock Entrance, opposite side	6·80	5·71	5·36	4·60	4·10	2·78	2·30	1·37	·72					
Whitehill Point, North side	7·03	5·94	5·59	4·83	4·33	3·01	2·53	1·60	·95	·23				
Mill Dam Landing-place, South Shields	7·33	6·24	5·89	5·13	4·63	3·31	2·83	1·90	1·25	·53	·30			
New Quay Landing-place, North Shields	7·80	6·71	6·36	5·60	5·10	3·78	3·30	2·37	1·72	1·00	·77	·47		
Low Lighthouse, North Shields	8·20	7·11	6·76	6·00	5·50	4·18	3·70	2·77	2·12	1·40	1·17	·87	·40	
Tynemouth Bar	8·96	7·87	7·52	6·76	6·26	4·94	4·46	3·53	2·88	2·16	1·93	1·63	1·16	·76

The distance from Tynemouth Bar to New Biggen Point is 13·32 statute miles, or 11·57 knots.

TABLE OF DISTANCES DOWN THE RIVER HUMBER, BY SHIP'S CHANNEL COURSE, FROM HULL ROADS TO SEA IN NAUTICAL MILES.

	Hull Roads, Citadel bearing N.	Hebble's Float	No. 7, Red Buoy	No. 10, Black Buoy	No. 9, Black Buoy	No. 8, Black Buoy	No. 6, Black Buoy	No. 3, Chequered Buoy	No. 3, Red Buoy	Bull Float	No. 1, Chequered Buoy
Hebble's Float	1·51										
No. 7, Red Buoy, or Paul Lighthouse, N.E. by E.	3·69	2·18									
No. 10, Black Buoy	6·08	4·57	2·39								
No. 9, Black Buoy, or Killingholme High Light, W. by S.	7·38	5·87	3·69	1·30							
No. 8, Black Buoy	9·12	7·61	5·43	3·04	1·74						
No. 6, Black Buoy	11·51	10·00	7·82	5·43	4·13	2·39					
No. 3, Chequered Buoy, or Grimsby Hydraulic Tower, W. by S.	14·54	13·03	10·85	8·46	7·16	5·42	3·03				
No. 3, Red Buoy	16·72	15·21	13·03	10·64	9·34	7·60	5·21	2·18			
Bull Float, or Spurn High Light, E.N.E.	19·32	17·81	15·63	13·24	11·94	10·20	7·81	4·78	2·60		
No. 1, Chequered Buoy	21·93	20·42	18·24	15·85	14·55	12·81	10·42	7·39	5·21	6·21	
Newsand Float, N.E.	23·66	22·15	19·97	17·58	16·28	14·54	12·15	9·12	6·94	4·34	1·73

The distance between No. 8, Black Buoy, and Spurn High Light, E.N.E. 1 mile, is 10·2 knots, or 11·5 statute miles.

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

TABLE OF DISTANCES FROM SOUTHAMPTON ROUND THE ISLE OF WIGHT THROUGH THE ST. HELEN'S PASSAGE, AND BACK TO SOUTHAMPTON THROUGH THE NEEDLES PASSAGE, IN NAUTICAL MILES.

Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

	Southampton Dock Entrance	Weston Red Buoy	Netley Hospital, East End	Calshot Light	Warner Light	Nab Light	Bonchurch, distant 1 mile N. by W.	St. Catharine's Point, distant 1 mile N.N.E.	Needles Light, distant ·8 mile E. by S. (Hurst Lights in 1)	Hurst Castle High Light	Calshot	Weston Red Buoy
Weston Red Buoy	1·2											
Netley Hospital, East End	2·8	1·6										
Calshot Light	6·8	5·6	4·0									
Measured Mile, West Posts in 1, distance ·6 mile	11·7	10·5	8·9	4·9								
Gilkicker Point, East Posts in 1, distance ·6 mile	12·7	11·5	9·9	5·9								
Warner Light	16·3	15·1	13·5	8·5								
Warner Light	16·2	15·0	13·4	9·4								
Nab Light	18·8	17·6	16·0	12·0	2·6							
Bonchurch, distant 1 mile N. by W.	27·2	26·0	24·4	20·4	11·0	8·4						
St. Catharine's Point, distant 1 mile N.N.E.	32·3	31·1	29·5	25·5	16·1	13·5	5·1					
Needles Light, dist. ·8 m. E. by S. (Hurst Lights in 1)	45·7	44·5	42·9	38·9	29·5	26·9	18·5	13·4				
Hurst Castle High Light	49·4	48·2	46·6	42·6	33·2	30·6	22·2	17·1	3·7			
Calshot	61·4	60·2	58·6	54·6	45·2	42·6	34·2	29·1	15·7	12·0		
Weston Red Buoy	67·0	65·8	64·2	60·2	50·8	48·2	39·8	34·7	21·3	17·6	5·6	
Southampton Docks	68·2	67·0	65·4	61·4	52·0	49·4	41·0	35·9	22·5	18·8	6·8	1·2

TABLE OF DISTANCES FROM DEVONPORT STEAM BRIDGE TO PLYMOUTH BREAKWATER, AND FROM THE BREAKWATER TO THE LIZARD WEST AND PORTLAND BILL EAST, IN NAUTICAL MILES.

	Devonport Steam Bridge	Block House	Asia White Buoy	Breakwater Light	Red and White Chequered Buoy	Beacon, East End of Breakwater	Little Mewstone	Bolt Head	Praul Point	Start Point
Block House, Devil's Point	1·60									
Asia White Buoy	2·60	1·00								
Breakwater Light, 1 cable-length W. by N.	4·60	3·00	2·00							
Red and White Chequered Buoy on Dray Stone	6·00	4·40	3·40	1·40						
Lizard, distant 2 miles N.	51·75	50·15	49·15	47·15	45·75					
Beacon, East End of Breakwater	4·20	2·60	1·60	—	—					
Little Mewstone, distant 3 cables East	6·20	4·60	3·60	—	—	2·00				
Bolt Head, distant 1 mile N.	20·70	19·10	18·10	—	—	16·50	14·50			
Praul Point, distant 1 mile N.	23·70	22·10	21·10	—	—	19·50	17·50	3·00		
Start Point, distant 1 mile N.	27·03	25·43	24·43	—	—	22·83	20·83	6·33	3·33	
Portland Bill, distant 2 miles N.	75·03	73·43	72·43	—	—	70·83	68·83	54·33	51·33	48·00

The distance from Plymouth Breakwater Light to the Eddystone Light is 10·156 knots, or 11·695 statute miles.
Note.—The nautical mile given in this table is the Admiralty knot of 6,080 lineal feet.

STEERING.

TURNING MOMENT OF RUDDER.

M = turning moment of rudder in foot lbs.

M_1 = moment of pressure of water on rudder relatively to its axis in foot lbs.

D = distance of centre of gravity of ship from centre of gravity of rudder surface in feet, measured along the middle line of ship.

d = distance of centre of effort from axis of rudder in feet.

V = velocity of current past rudder in feet per second (can generally be taken as 1·1 × velocity of ship in feet per second).

A = area of rudder surface in square feet.

P = normal pressure on rudder in lbs.

L = longitudinal component of P = direct head resistance of rudder.

T = lateral component of P tending to turn ship.

θ = angle rudder makes with the middle line of ship.

k = constant = 1·12.

$M = k \,.\, A \,.\, V^2 \,.\, D \,.\, \sin\theta \,.\, \cos\theta.$ $\qquad L = k \,.\, A \,.\, V^2 \,.\, \sin^2\theta.$

$M_1 = k \,.\, A \,.\, V^2 \,.\, d \,.\, \sin\theta.$ $\qquad T = k \,.\, A \,.\, V^2 \,.\, \sin\theta \,.\, \cos\theta.$

$P = k \,.\, A \,.\, V^2 \,.\, \sin\theta.$

Note.—With the ship going ahead, the centre of effort at an angle of 35° is about $\frac{1}{8}$ of the breadth of the rudder before the centre of gravity of the rudder area; with the ship going astern it is about the same amount abaft.

BEST BREADTH OF RUDDER.

The best breadth of rudder for a ship when moving at a given speed is that which allows it to be put over to an angle of 45° from the middle line of the ship.

PROPORTION OF RUDDER SURFACE TO AREA OF LONGITUDINAL IMMERSED SECTION IN SOME OF H.M. SCREW SHIPS.

Name of Ship	Area of Rudder in Square Feet	Area of Longitudinal Vertical Section in Square Feet	Area of Section Divided by Area of Rudder	Name of Ship	Area of Rudder in Square Feet	Area of Longitudinal Vertical Section in Square Feet	Area of Section Divided by Area of Rudder
Achilles .	166	9792	59·0	Glatton .	163	4579	28·0
Arethusa .	114	5359	47·0	Inconstant .	191	7640	40·0
Bellerophon .	248	7301	29·4	Minotaur .	198	10367	52·4
Blonde . .	203	7455	36·7	Monarch .	231	7652	33·1
Canopus .	127	4592	36·1	Raleigh .	109	3854	35·3
Cyclops .	95	3613	38·1	Himalaya .	105	6290	60·0
Devastation .	165	7615	46·1	Warrior .	180	9271	51·5
Volage . .	117	4485	38·3	Sanspareil .	189	9129	48·3
Swift . .	39	1691	43·4	Blenheim .	227	9416	41·0
Benbow .	187	8976	48·0	Grafton .	205	8354	40·7

A Practical Method of Measuring the Circle Described by a Ship. (*F. Martin, M.I.N.A.*)

Fig. 189 shows the small portable fittings to be used on the occasion. A is a quadrant with the degrees carefully marked on a piece of wood which is temporarily secured on the ship's rail, with its inner edge AB kept parallel to the middle line of the ship; C is a batten about 4 feet long and 3 inches broad, with two upright wire sights S, S, one in each end, about 8 inches long. The batten is placed on the quadrant, with the centre of one end coinciding with the centre of the quadrant, and fixed with a pin through the centre, so that it can revolve. A base (AB, fig. 189*a*) is set off in a fore and aft direction, of any convenient length, and at its foremost extremity a straight batten D is fixed vertically to the ship's side, extending a few feet above the rail. The same arrangement is carried out on each side of the ship, and a line joining the edges of the battens D, D must be at right angles to the middle line of the ship. These are all the fittings necessary. When the helm is hard over, and the ship has fairly commenced her circular course, throw overboard a rough wood box about a foot square and painted black: as the ship moves onwards the box remains nearly stationary on the water, till presently the ship has described a semicircle, which is known by the two battens D, D and the box coming into the same straight line. At that instant the batten C is made to revolve till the two wire sights S, S and the box are in the same straight line; the angle A (fig. 189*a*) is then known, being denoted by the batten C on the quadrant. The angle B is a right angle, and the base AB being known, then DO = tangent A × BA, to which must be added twice the breadth of the ship for the greatest space occupied by her in describing the circle.—*Ex.*: If the angle A = 80° 15′, and the base BA = 90 feet, and the breadth of the vessel = 40 feet, then the greatest space occupied by her in describing the circle is = (90 × 5·81965) + (2 × 40) = 603·768 feet.

Fig. 189.

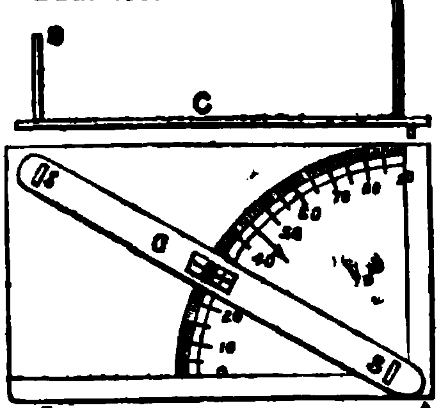
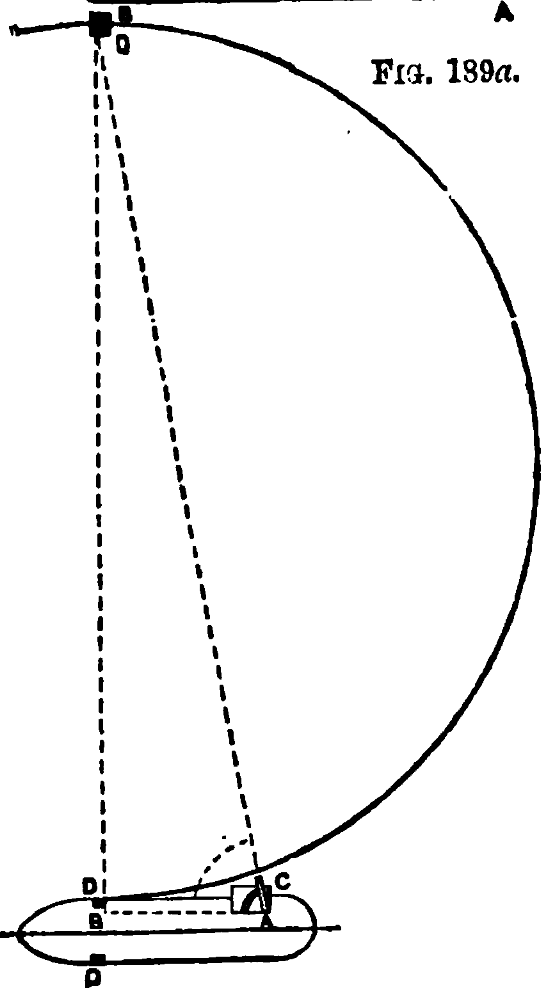


Fig. 189*a*.



NOTES ON STEERING.

Balanced rudders have on an average about one-third their area before the centre of pivot. If the screw is right-handed the head of ship will tend to move to starboard, and *vice versâ*.

In determining the velocity of water impressions upon the rudder, take the speed of the ship plus the slip of the screw. The centre of effort for ordinary rudders may be taken at about one-third to one-fourth of the mean breadth of the rudder, and in a balanced rudder at the axis.

Four features chiefly affect the readiness of a ship to answer helm: (1) Time occupied in putting helm hard over; (2) rudder pressure corresponding to that position; (3) moment of inertia of ship about vertical axis passing through the centre of gravity; (4) moment of resistance to rotation. The diameter of circle turned in has been found to vary between six and eight times the length of ship with ordinary rudders, and from four to five times with balanced rudders, using manual power only.

With steam power the circle turned in with ordinary rudders about four times the length of ship, and with balanced rudders less than three times the length.

Rudder areas may be proportioned as follows:—A_1 and A_2 = middle line planes of two similar ships, a_1 and a_2 the rudder areas, l_1 and l_2 the lengths; then $\frac{a_1}{a_2} = \frac{A_1}{A_2}\left(\frac{l_1}{l_2}\right)^2$.

Terms used with reference to the tiller:

Helm *a-starboard*, or inclined towards the right.	Means that rudder is *a-port*, or inclined towards the left.
Helm *a-port*, or inclined towards the left.	Means that rudder is *a-starboard*, or inclined towards the right.
Helm *a-lee*, or inclined to leeward.	Means that rudder is *a-weather*, or inclined to windward.
Helm *a-weather*, or inclined windward.	Means that rudder is *a-lee*, or inclined to leeward.

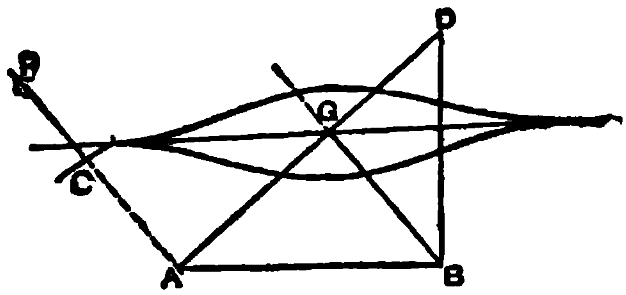
Steering Indicator.—Tiller and indicator should move the same way; rudder, wheel, and ship's head should move the same way, and opposite, of course, to tiller and indicator.

In the balanced rudder the axis of motion is about $\frac{1}{3}$ of the breadth of the rudder from the forward edge, and the rudder turns on a pivot at its lower end; with $\frac{1}{3}$ of the breadth before, and $\frac{2}{3}$ abaft the axis, the rudder tends to come to a fore and aft position.

For good steering it is necessary that there are no eddies at the stern, and that the water flows steadily past the ship, so that the fairness and fineness essential for speed are also necessary for good steering.

The first action of the rudder when it is put over, tends to turn the ship about an instantaneous axis, which is found as follows (fig. 190): CP = pressure of water on rudder from G, the centre of gravity of ship, draw GB parallel to CP, making GB = radius of

FIG. 190.



gyration of the ship; draw GA perpendicular to PC, and join AB; draw BD perpendicular to AB, meeting AG, produced in D; then D is the instantaneous axis about which the ship turns; when the sideward drifting of the ship becomes equal to the transverse component of the pressure on the rudder, the ship goes on turning about its centre of lateral resistance under the action of a couple = PC multiplied by the distance between C and the centre of lateral resistance.

The centre of lateral resistance generally lies before the middle of the vessel's length, so that the stern is the most efficient position for the rudder.

The angular velocity with which the vessel turns is that at which the moment of resistance of the water to her turning is equal to the moment of the couple just mentioned. In ordinary cases the diameter of the circle is about 6 to $6\frac{1}{2}$ times the length of the vessel.

The resistance to turning is diminished by cutting away the forefoot and deadwood as much as possible; but this tends to injure her weatherliness, and steadiness in a seaway.

The extreme breadth of the rudder by the old practice was about $\frac{1}{30}$ of the length of the load line; in steamers it varies from $\frac{1}{40}$ to $\frac{1}{50}$ of the length.

RELATION BETWEEN THE POWER APPLIED AND THE EFFECT OF THE RUDDER TO TURN THE SHIP. (F. K. BARNES, M.I.N.A.)

Let two rudders (fig. 191) be fitted, and let B, b be their breadths, and let θ, θ_1 be the angles of rudder with same power applied.

K = resistance per unit for surface moving perpendicular to itself.

G = centre of gravity of ship.

GP or G$p = l$. $\therefore$ GM $= l \cos \theta$, and G$m = l \cos \theta_1$.

S = speed of ship in knots per hour.

Then pressure on wide rudder $= \text{KS}^2 \sin^2 \theta \text{B}$ per unit of depth of rudder;

" " " narrow rudder $= \text{KS}^2 \sin^2 \theta_1 b$ per unit of depth of rudder;

and moments of these pressures about axis of rudder

$$= \text{KS}^2 \sin^2 \theta \text{B} \times \frac{\text{B}}{2} \text{ and } \text{KS}^2 \sin^2 \theta_1 b \times \frac{b}{2}.$$

But these moments are equal.

$$\therefore \text{KS}^2 \sin^2 \theta \frac{\text{B}^2}{2} = \text{KS}^2 \sin^2 \theta_1 \frac{b^2}{2}.$$

$$\text{B}^2 \sin^2 \theta = b^2 \sin^2 \theta_1.$$

$$\therefore \text{B} \sin \theta = b \sin \theta_1.$$

$$\therefore \text{KS}^2\text{B} \sin \theta l = \text{KS}^2 b \sin \theta_1 b \quad . \; . \; . \; (1).$$

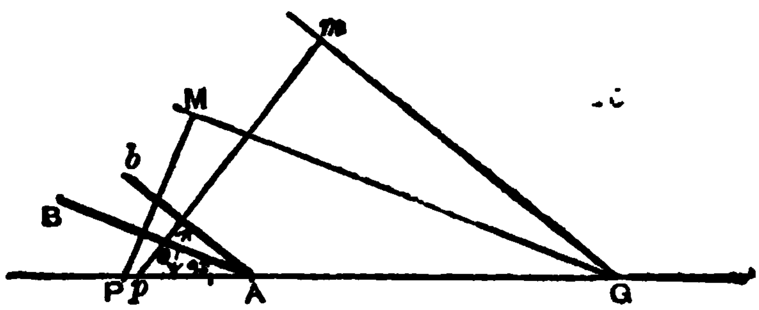
Turning effect of broad rudder $= \text{KS}^2 \sin^2 \theta l \cos \theta \text{B}$.

" " " narrow rudder $= \text{KS}^2 \sin^2 \theta_1 l \cos \theta_1 b$.

Dividing by (1) we get

$$\frac{\text{Broad rudder}}{\text{Narrow rudder}} = \frac{\sin \theta \cos \theta}{\sin \theta_1 \cos \theta_1} = \frac{\sin 2\theta}{\sin 2\theta_1}.$$

FIG. 191.



BARREL OF STEERING-WHEEL.

To determine the taper of barrel.—

1st, determine the length of tiller.

2nd, arrange the blocks and sheaves to put helm over to 40°.

3rd, decide the number of turns to put helm over, say, 3.

4th, obtain diameter of barrel, as follows:—

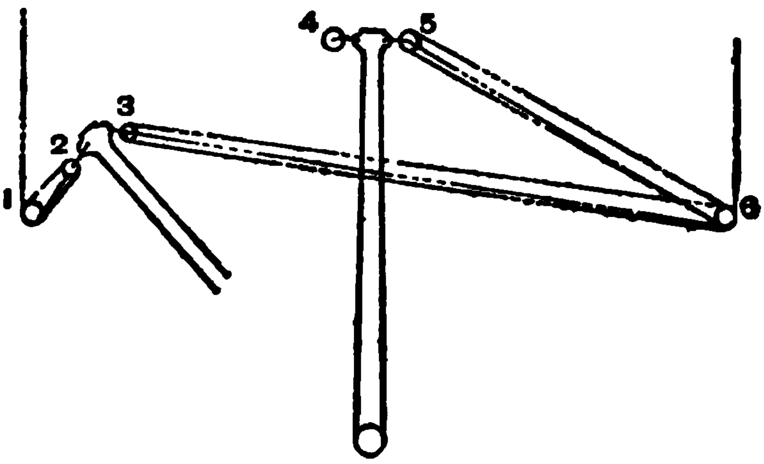
Set off the position of the block and sheaves as per sketch. Then measure the distance from centre to centre of sheaves, as, for instance, from 1—4, 1—2, 3—6, which will be found, as per sketch, to be as follows: 1—4 = 4·94, 1—2 = 1·67, and 3—6 = ·74.

Multiply these distances by the number of parts of rope between the sheaves, which is 3, and the result will be 3 times 1—4 = 14·82, 3 times 1—2 = 5·01, 3 times 3—6 = 23·22.

It is evident that the rope taken out by putting the helm

hard over is the difference of rope between 3 times 1—4 and 3 times 1—2, viz., $14·82 - 5·01 = 9·81$. This is to be taken up in 3 turns; $\therefore \frac{9·81}{3} = 3·27$ must be the length taken up in one turn, and is the circumference of the barrel at the middle of the

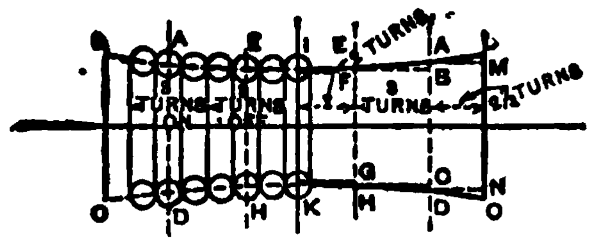
FIG. 192.



3 turns taken on the barrel in putting the helm hard over. $\therefore \frac{3·27}{3·1416} = 1·04$, diameter of barrel at this place. Again, the rope given out by putting the helm over is the difference between 3 times 3—6 and 3 times 1—4 (5 to 6 being = 1 to 4; *i.e.*, $23·22 - 14·82 = 8·4$. This is to be given out in 3 turns). $\frac{8·4}{3} = 2·8$ must be the length given out in one turn, and is therefore the circumference of the barrel at the middle of the 3 turns which came off the barrel in putting the helm over. $\therefore \frac{2·8}{3·1416} = ·891$, diameter of barrel at this place (see fig. 193).

Having now succeeded in getting the diameter of the barrel at the places referred to, we will proceed by calculation to obtain the diameter at middle and at ends of barrel. It will be

FIG. 193.



seen in fig. 2 that AB = CD and EF = GH, and that EF = $\frac{2}{3}$AB; also GH = $\frac{2}{3}$CD. $\therefore$ EF + GH = $\frac{2}{3}$(AB + CD), and AB + CD = AD − EH. $\therefore$ diameter at middle or IK = EH − (EF + GH) = EH − $\frac{2}{3}$(AB + CD) = EH − $\frac{2}{3}$(AD − EH). Now, EH = ·891, and AD = 1·04. $\therefore$ diameter at middle or IK = $·891 - \frac{2}{3}(1·04 - ·891) = ·742$. Next, for diameter

at ends of barrel, LM = NO, and diameter LO at end of barrel = AD + (LM + NO), and LM + NO = $1\frac{1}{4}$(EF + GH), because AM = $2\frac{1}{2}$ diameter of rope, and IF = 2 diameters, and EF + GH = $\frac{2}{3}$(AB + CD) = $\frac{2}{3}$(AD − EH) = $\frac{2}{3}$(1·04 − ·891), and diameter at end = AD + $1\frac{1}{4}$ × $\frac{2}{3}$(1·04 − ·891) = 1·224.

The length of barrel is obtained by measuring the space required for the number of turns of the rope that it is determined shall be on the barrel, which we will suppose to be 7, sometimes 5, at others 9, have been adopted; but there must always be an odd number, to allow of the centre turn being secured to the barrel in order to prevent the rope from slipping when a strain is brought upon it. The diameter of the rope in this case being $1\frac{1}{2}''$, $7 \times 1\frac{1}{2} = 10\frac{1}{2}$ will give $5\frac{1}{4}$ ins. on each side of the middle; and as the helm is to be over in 3 turns the exact length it will be $(5\frac{1}{4} + 4\frac{1}{2}) \times 2 = 19\frac{1}{2}$; but as the rope shall not be too closely confined it is desirable to have 3 ins. additional length.

General Remarks.

1st. The larger the tiller the greater will be the diameter of the barrel, and *vice versâ.*

2nd. A double purchase will require a larger barrel than a single, and a greater number of turns to put the helm over.

3rd. The actual diameter of the barrel will be one diameter of the rope less than the calculated dimensions, as may be seen by referring to fig. 193, the calculated dimensions being from centre to centre of rope.

4th. When diameter at EH and AD are obtained, and are set out in their positions, the lines AE and HD produced will give the diameter of the barrel at end and middle without calculation near enough for all practical purposes.

LAUNCHING.

LAUNCHING CALCULATIONS.

Before constructing a set of launching curves the moment of weight about the fore poppet is found; this is constant, and is represented by a line parallel to base line (see fig. 194). The moments of buoyancy about the fore poppet, and also about the after end of ways, and the displacement of the ship are calculated at equal intervals apart, as the ship moves down the ways. The moment of weight about the after end of ways is also found, this will be zero when the centre of gravity of the ship is vertically over the end of the ways.

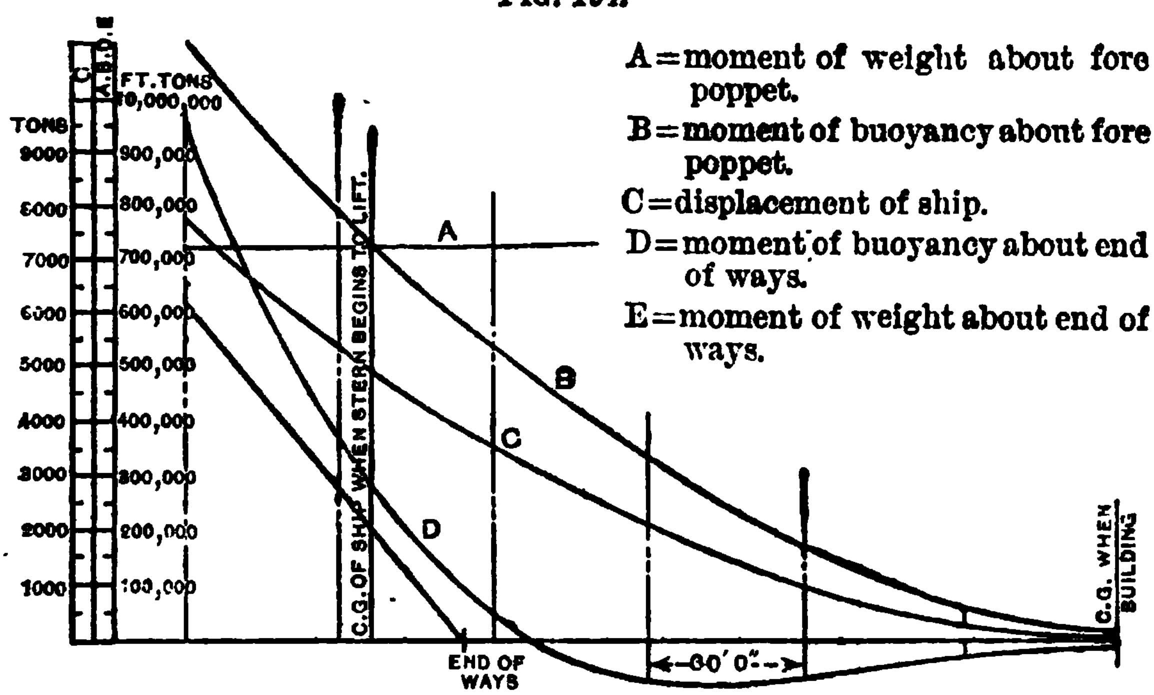
The diagram (fig. 194) represents the launching curves for H.M.S. 'Sanspareil;' calculated from the following particulars.

Draught of water, forward 15′ 0″, aft 20′ 0″.
Displacement at this draught 5,746 tons.
Inclination of blocks for building $\frac{5}{8}''$ to a foot.
Inclination of ways greatest $\frac{13}{16}''$, least $\frac{11}{16}''$.

Draught of water on end of ways 15′ 0″.
Pressure per square foot on ways 2·92 tons.

When the curves of buoyancy and weight about the fore poppet intersect the moments are equal, and therefore the ship will commence to lift; but they actually slide from 15 to 30 feet

Fig. 194.



beyond this point before doing so, according to the weight of the ship and the fineness of the after body.

The ordinate to the curve of displacement at this point represents the displacement of vessel when the stern begins to lift, and this deducted from the total weight gives weight on foremost poppets, which in this case was 435 tons on each poppet. The poppets must, of course, be made strong enough, and the bottom of ship stiffened in wake of them to stand this strain. The difference between the curves D and E gives the moment against tripping; this cannot come into action until the centre of gravity of the ship has passed the end of the ways. If there is a negative moment at this point the head of the ship will be lifted off the ways, and thus throw the whole weight on the end of the ways, and even if the ways do not give way at this point the bottom of the ship will be damaged owing to the excessive strain.

Launching Velocities.

A strong cord is attached to bow of the vessel, passing over a disc of known diameter. As the launch proceeds the cord in following the ship turns the disc in unrolling itself from a reel. A shaft through centre of disc communicates motion to a drum, round which a sheet of paper is firmly fixed, and upon which a small pen, filled with aniline dye, actuated by an electric clock makes one jerk every half-second.

Knowing the velocity of drum relatively to that of the disc, it is easy to find the velocity of ship at any half-second from the diagram.

Two curves are plotted from this diagram.

1st. Distance along base represents seconds, and ordinates to represents speed per second.

2nd. Distance along base represents distance vessel has moved in feet, and ordinates represents speed per second at that point.

The dip of the stern is also observed from a boat, placed sufficiently near to be out of the way of the launch, but near enough to get a pretty accurate result.

Fig. 195.

S.S. QUETTA.
380′×40′×30′6″

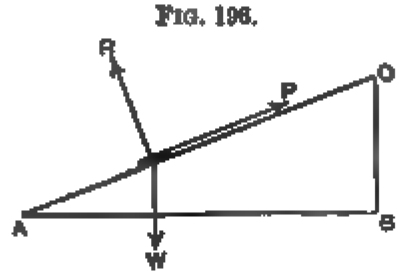
Scale of Seconds

(Taken from *Trans. Inst. Naval Architects*, from an article on 'Launching Velocities.' By W. Denny, Esq., F R.S.E. Vol. xxiii.)

Weight acting on Dogshores, etc.

Construct an inclined plane to represent the sliding ways (see fig. 196).

Fig. 196.



Let W = weight of ship
R = reaction of ways.
θ = inclination of ways.
u = coefficient of friction, say ·04.

Force of friction = uR. R = W cos θ.

Resolved part of weight acting down the plane W sin θ.

$\therefore$ Total force acting down plane = W sin $\theta - u$ W cos θ.

Weight acting on dogshores = W (sin $\theta - u$ cos θ).

In the case of H.M.S. Sanspareil = 128 tons.

Force required to draw a vessel up the ways.—Using the same notation as before.

Force of friction = u R = u W . cos θ.

Resolved part of weight down ways = W sin θ.

$\therefore$ Total force required = W (sin $\theta + u$ cos θ).

TABLE OF LAUNCHING DATA.*

Name of Steamer	Bancoora	Diana	Kerbela	Quetta	Clyde	India	Antonio Lopez	Mahana-pua	Bucarest	Goorkha
Moulded dimensions	328' × 40' × 28' 6"	160' × 20' × 9'	290' × 36' × 26' 6"	380' × 40' × 30' 6"	380' × 42' × 34'	390' × 49' × 31'	370' × 42' × 30'	160' × 26' 10" × 18' 1"	250' × 37' × 24'	390' × 42' × 31'
Date of launch	19 Nov. 1880	3 Sept. 1880	6 Oct. 1880	1 Mar. 1881	15 June 1881	27 Aug. 1881	8 Nov. 1881	31 Dec. 1881	20 Dec. 1881	7 Mar. 1882
Temperate of air Fahrenheit	—		·	—	60°	56°	53°	67·5°	40°	46°
... of an	6 to 12	6 to 20	7 to 16	8 to 16	7 to 18	7 to 12	9 to 11	8 to 18	6 to 11	8 to 12
	5' 2"	4' 10"	4' 9"	6' 6"	4' 8"	5' 6"	6' 6"	4' 9"	4' 9"	7' 1½"
Draughts of ship forward	6' 10"	9' 1½"	7' 8"	8' 7½"	8' 9"	7' 8"	8' 2"	5' 6"	5' 10½"	7' 11½"
" " aft	8' 7"	6' 9"	8' 11"	10' 7½"	12' 9"	10' 5"	10' 10½"	5' 0"	8' 10½"	10' 6"
" " mean	7' 8½"	9' 7½"	6' 8½"	9' 7½"	10' 6"	9' 0"	9' 6½"	4' 2"	7' 4"	9' 2½"
Displacement in tons	1660	164	1246	2075	2585	2125	1944	226	1108	2109
	545'	—	265'	409'	414'	431'	302'	251'	260'	400'
	245'	114'	209'	292'	301'	296'	222'	112'	196'	300'
	22"	16"	22"	22"	22"	20"	26"	16"	16"	22"
	940	235	601	1104	1150	1142	1037	220	466	1160
... of	1·05	·56	1·55	1·87	2·25	1·06	1·80	·05	2·20	1·90
... r	12' 6"	—	16'	19'	20'	17'	15' 6"	—	13' 9"	16' 6"
... ty	185'	170'	247'	263'	280'	260'	216'	170'	140'	230'
	16' 9"	—	20' 5"	24' 7"	19' 9"	20' 8"	19' 6"	14' 7"	12' 1"	19' 4"
... y	6' 6"	10' 0"	12' 6"	12' 2"	12' 4"	10' 9"	10'	6' 4"	6' 1"	9' 2"
	40"	20"	40"	45"	45"	40"	44"	45"	45"	34"
	30"	27"	33"	30"	34"	35"	60"	30"	33"	67"
	15·3	16·7	17·7	16·45	16·4	14·7	16·6	16·7	14·4	12
	9·06	6·11	10·6	9·74	9·71	8·70	8·80	8·11	8·88	7·16
... second	8·38	—	9·16	9·31	9·68	9·24	8·91	6·84	5·64	4·98
	12·9	19·45	16·6	12·95	15	12·6	12·9	–	11·9	10
	6·54	6·30	7·46	7·66	8·28	7·45	7·08	4·72	5·65	5·05
... between ... points of maximum velocity	26·7	28·4	26·4	29·1	28·2	25·4	25·3	28·3	19·7	24·2

* From *Transactions of the Institution of Naval Architects*,

Estimation of Quantities.

Tons × 2240 = lbs. Tons × 20 = cwts. Lbs. × ·000446428 = tons.

Weight of Round or Elliptical Bars.

Diameter × diameter × length in feet × constant = weight in lbs.

Weight of Square or Rectangular Bars.

Width × thickness × length in feet × constant = weight in lbs.

Weight of Plating or Planking.

Thickness × breadth in feet × length in feet × constant = weight in lbs.

Values of Constants for Round or Elliptical Bars.

Material	Diameters taken in					
	Ins.	½ In.	¼ In.	⅛ In.	$\frac{1}{16}$ In.	$\frac{1}{32}$ In.
Brass, sheet . .	2·905980	·726495	·181624	·045406	·011351	·002838
Iron, wrought . .	2·61800	·654500	·163625	·040906	·010227	·002557
Lead, sheet . .	3·88773	·971933	·242983	·060746	·015186	·003797
Steel, soft . . .	2·67036	·667590	·166898	·041724	·010431	·002608
Elm, American . .	·261800	·065450	·016363	·004091	·001023	·000356
Mahogany, Honduras	·196350	·049088	·012272	·003068	·000767	·000192
,, Spanish .	·287980	·071995	·017999	·004500	·001125	·000281
Oak, Dantzic . .	·261800	·065450	·016363	·004091	·001023	·000356
,, English . .	·307615	·076904	·019228	·004807	·001202	·000300
Pine, red . . .	·196350	·049088	·012272	·003068	·000767	·000192
,, yellow . .	·157080	·039270	·009818	·002454	·000614	·000153
Teak, Indian . .	·287980	·071995	·017999	·004500	·001125	·000281

Values of Constants for Square or Rectangular Bars.

Material	Width and Thickness taken in					
	Ins.	½ In.	¼ In.	⅛ In.	$\frac{1}{16}$ In.	$\frac{1}{32}$ In.
Brass, sheet . .	3·70000	·925000	·231250	·057813	·014453	·003613
Iron, wrought . .	3·33333	·833333	·208333	·052083	·013021	·003255
Lead, sheet . .	4·95000	1·23750	·309375	·077344	·019336	·004834
Steel, soft . . .	3·40000	·850000	·212500	·053125	·013281	·003320
Elm, American . .	·333333	·083333	·020833	·005208	·001302	·000326
Mahogany, Honduras	·250000	·062500	·015625	·003906	·000977	·000244
,, Spanish .	·366667	·091667	·022917	·005729	·001432	·000358
Oak, Dantzic . .	·333333	·083333	·020833	·005208	·001202	·000326
,, English . .	·391667	·097917	·024479	·006120	·001530	·000382
Pine, red . . .	·250000	·062500	·015625	·003906	·000977	·000244
,, yellow . .	·200000	·050000	·012500	·003125	·000781	·000195
Teak, Indian . .	·366667	·091667	·022917	·005729	·001432	·000358

Values of Constants for Plating or Planking.

Material	Thickness taken in						
	Ins.	½ In.	¼ In.	⅛ In.	$\frac{1}{16}$ In.	$\frac{1}{32}$ In.	$\frac{1}{64}$ In.
Brass, sheet . .	44·4	22·2	11·100	5·550	2·7750	1·38750	·69375
Iron, wrought . .	40·0	20·0	10·000	5·000	2·5000	1·25000	·62500
Lead, sheet . .	59·4	29·7	14·85	7·425	3·7125	1·85625	·92813
Steel, soft . . .	40·8	20·4	10·20	5·100	2·5500	1·27500	·63750
Elm, American . .	4·00	2·00	1·000	·5000	·25000	·12500	·62500
Mahogany, Honduras	3·00	1·50	·750	·3750	·18750	·09375	·04688
,, Spanish .	4·40	2·20	1·100	·5500	·27500	·13750	·06875
Oak, Dantzic . .	4·00	2·00	1·000	·5000	·25000	·125000	·06250
,, English . .	4·70	2·35	1·175	·5875	·29375	·14688	·07344
Pine, red . . .	3·00	1·50	·750	·3750	·18750	·09375	·04688
,, yellow . .	2·40	1·20	·600	·3000	·15000	·07500	·03750
Teak, Indian . .	4·40	2·20	1·100	·5500	·27500	·13750	·06875

Weight of Pipes.

W = weight per lineal foot in lbs. D = outside diameter in ins.
K = constant from below. d = inside „ „

$$W = (D^2 - d^2)K.$$

Values of K *for Pipes.*

Brass = 2·9060.	Iron, cast = 2·4282.	Lead = 3·8877.
Copper = 2·9943.	„ wrought = 2·6180.	Steel = 2·6704.

Weight of Angle Iron.

W = weight in lbs. per lineal foot. S = sum of the widths of flanges in ins.
T = thickness of flanges in ins.

$$W = T(S - T)\ 3{\cdot}33333.$$

Relative Weights of Different Substances.

Wrought iron = 1.

Brass, sheet	= 1·1100.	Beech	= ·0896.	Oak, English	= ·1175.
Copper „	= 1·1438.	Elm	= ·1000.	Pine, red	= ·0750.
Iron, cast	= ·9275.	Fir, spruce	= ·0833.	„ yellow	= ·0600.
Lead, sheet	= 1·4850.	Mahogany, Honduras	= ·0750.	Sycamore	= ·0808.
Steel, soft	= 1·0200.	„ Spanish	= ·1100.	Teak, African	= ·1145.
Tin	= ·9500.	Maple	= ·1021.	„ Indian	= ·1277.
Zinc	= ·9494.	Oak, Dantzic	= ·1000.	Willow	= ·0521.

Weight, &c., of Fresh Water.

A cubic foot	= ·0279 ton	= 62·39 lbs.	= 998·18 avd. ozs.	= 6·2321 galls.
A cubic inch	= ·0361 lb.	= ·5776 avd. oz.	= ·0336 gall.	
A gallon	= ·0045 ton	= 10·000 lbs.	= 160·15 avd. ozs.	= ·16044 cu. ft.
A ton	= 35·905 cu. ft.	= 2240 lbs.	= 223·76 galls.	

Weight of fresh water = weight of salt water × ·9740.

Weight, &c., of Salt Water.

A cubic foot	= ·0286 ton	= 64·05 lbs.	= 1024·80 avd. ozs.	= 6·2321 galls.
A cubic inch	= ·0371 lb.	= ·5930 avd. oz.	= ·0036 gall.	
A gallon	= ·0046 ton	= 10·276 lbs.	= 164·41 avd. ozs.	= ·16044. cu. ft.
A ton	= 34·973 cu. ft.	= 2240 lbs.	= 217·95 galls.	

Note.—A cubic foot of salt water is usually taken at 35 cu. ft. to the ton and 64 lbs. to the cubic foot, fresh water being taken at 36 cu. ft. to the ton and 62·25 lbs. to the cubic foot.

Miscellaneous Factors.

A ton	= 1·01605 tonne or tonneau.	A tonne or tonneau	= ·984206 ton.
An avd. lb.	= ·45359 kilogram.	A kilogram	= 2·20462 lbs.
A foot	= ·304797 metre.	A metre	= 3·2808693 feet.
A sq. foot	= ·092901 sq. metre.	A sq. metre	= 10·7641 sq. feet.
A sq. inch	= 645·148 sq. millimetres.	A sq. millimetre	= ·00155008 sq. in.
A cu. ft.	= ·028316 cu. metre.	A cubic metre	= 35·3156 cu. feet.
A cubic yard	= ·764534 cu. metre.	„ „	= 1·30799 cu. yd.
A mile	= 1·60933 kilometre.	A kilometre	= ·621377 mile.
Knot per hour	= 1·688 foot per second.	Foot per second	= ·592 knot per hour.
„ „	= ·5144 metre per second.	Metre per second	= 1·944 knot per hour.
Mile per hour	= 1·467 foot per second.	Foot per second	= ·682 mile per hour.
A gallon	= 4·54102 litres.	A litre	= ·220215 gallon.

Table of the Weight of Malleable Flat Iron in Lbs. per Lineal Foot.

Breadth of Plate (ins.)	Thickness in Fractions of an Inch																Breadth of Plate (ins.)
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	
1	·21	·42	·63	·83	1·04	1·25	1·46	1·67	1·88	2·08	2·29	2·50	2·71	2·92	3·13	3·33	1
$1\frac{1}{4}$	·26	·52	·78	1·04	1·30	1·56	1·82	2·08	2·34	2·60	2·86	3·13	3·39	3·65	3·91	4·16	$1\frac{1}{4}$
$1\frac{1}{2}$	·31	·63	·94	1·25	1·56	1·88	2·19	2·50	2·81	3·13	3·44	3·75	4·06	4·38	4·69	5·00	$1\frac{1}{2}$
$1\frac{3}{4}$	·36	·73	1·09	1·46	1·82	2·19	2·55	2·92	3·28	3·65	4·01	4·38	4·74	5·10	5·47	5·83	$1\frac{3}{4}$
2	·42	·83	1·25	1·67	2·08	2·50	2·92	3·33	3·75	4·17	4·58	5·00	5·42	5·83	6·25	6·67	2
$2\frac{1}{4}$	·47	·94	1·41	1·88	2·34	2·81	3·28	3·75	4·22	4·69	5·16	5·63	6·09	6·56	7·03	7·50	$2\frac{1}{4}$
$2\frac{1}{2}$	·52	1·04	1·56	2·08	2·60	3·13	3·65	4·17	4·69	5·21	5·73	6·25	6·77	7·29	7·81	8·33	$2\frac{1}{2}$
$2\frac{3}{4}$	·57	1·15	1·72	2·29	2·86	3·44	4·01	4·58	5·16	5·73	6·30	6·88	7·45	8·02	8·59	9·17	$2\frac{3}{4}$
3	·63	1·25	1·88	2·50	3·13	3·75	4·38	5·00	5·63	6·25	6·88	7·50	8·13	8·75	9·38	10·00	3
$3\frac{1}{4}$	·68	1·35	2·03	2·71	3·39	4·06	4·74	5·42	6·09	6·77	7·45	8·13	8·80	9·48	10·16	10·83	$3\frac{1}{4}$
$3\frac{1}{2}$	·73	1·46	2·19	2·92	3·65	4·38	5·10	5·83	6·56	7·29	8·02	8·75	9·48	10·21	10·94	11·67	$3\frac{1}{2}$
$3\frac{3}{4}$	·78	1·56	2·34	3·13	3·91	4·69	5·47	6·25	7·03	7·81	8·59	9·38	10·16	10·94	11·72	12·50	$3\frac{3}{4}$
4	·83	1·67	2·50	3·33	4·17	5·00	5·83	6·67	7·50	8·33	9·17	10·00	10·83	11·67	12·50	13·33	4
$4\frac{1}{4}$	·89	1·77	2·66	3·54	4·43	5·31	6·20	7·08	7·97	8·85	9·74	10·63	11·51	12·40	13·28	14·17	$4\frac{1}{4}$
$4\frac{1}{2}$	·94	1·88	2·81	3·75	4·69	5·63	6·56	7·50	8·44	9·38	10·31	11·25	12·19	13·13	14·06	15·00	$4\frac{1}{2}$
$4\frac{3}{4}$	·99	1·98	2·97	3·96	4·95	5·94	6·93	7·92	8·91	9·90	10·89	11·88	12·86	13·85	14·84	15·83	$4\frac{3}{4}$
5	1·04	2·08	3·13	4·17	5·21	6·25	7·29	8·33	9·38	10·42	11·46	12·50	13·54	14·58	15·63	16·67	5
$5\frac{1}{4}$	1·09	2·19	3·28	4·38	5·47	6·56	7·66	8·75	9·84	10·94	12·03	13·13	14·22	15·31	16·41	17·50	$5\frac{1}{4}$
$5\frac{1}{2}$	1·15	2·29	3·44	4·58	5·73	6·88	8·02	9·17	10·31	11·46	12·60	13·75	14·90	16·04	17·19	18·33	$5\frac{1}{2}$
$5\frac{3}{4}$	1·20	2·40	3·59	4·79	5·99	7·19	8·39	9·58	10·78	11·98	13·18	14·38	15·57	16·77	17·97	19·17	$5\frac{3}{4}$
6	1·25	2·50	3·75	5·00	6·25	7·50	8·75	10·00	11·25	12·50	13·75	15·00	16·25	17·50	18·75	20·00	6
Breadth of Plate (ins.)	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch																

Table of the Weight of Malleable Flat Iron in Lbs. per Lineal Foot (concluded).

Breadth of Plate (ins.)	Thickness in Fractions of an Inch																Breadth of Plate (ins.)
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	
6¼	1.30	2.60	3.91	5.21	6.51	7.81	9.11	10.42	11.72	13.02	14.32	15.63	16.93	18.23	19.53		6¼
6½	1.35	2.71	4.06	5.42	6.77	8.13	9.48	10.83	12.19	13.54	14.90	16.25	17.60	18.96	20.31		6½
6¾	1.41	2.81	4.22	5.63	7.03	8.44	9.84	11.25	12.66	14.06	15.47	16.88	18.28	19.69	21.09		6¾
7	1.46	2.92	4.38	5.83	7.29	8.75	10.21	11.67	13.13	14.58	16.04	17.50	18.96	20.42	21.88		7
7¼	1.51	3.02	4.53	6.04	7.55	9.06	10.57	12.08	13.59	15.10	16.61	18.13	19.64	21.15	22.66		7¼
7½	1.56	3.13	4.69	6.25	7.81	9.38	10.94	12.50	14.06	15.63	17.19	18.75	20.31	21.88	23.44		7½
7¾	1.61	3.23	4.84	6.46	8.07	9.69	11.30	12.92	14.53	16.15	17.76	19.38	20.99	22.60	24.22		7¾
8	1.67	3.33	5.00	6.67	8.33	10.00	11.67	13.33	15.00	16.67	18.33	20.00	21.67	23.33	25.00		8
8¼	1.72	3.44	5.16	6.88	8.59	10.31	12.03	13.75	15.47	17.19	18.91	20.63	22.34	24.06	25.78		8¼
8½	1.77	3.54	5.31	7.08	8.85	10.63	12.40	14.17	15.94	17.71	19.48	21.25	23.02	24.79	26.56		8½
8¾	1.82	3.65	5.47	7.29	9.11	10.94	12.76	14.58	16.41	18.23	20.05	21.88	23.70	25.52	27.34		8¾
9	1.88	3.75	5.63	7.50	9.38	11.25	13.13	15.00	16.88	18.75	20.63	22.50	24.38	26.25	28.13		9
9¼	1.93	3.85	5.78	7.71	9.64	11.56	13.49	15.42	17.34	19.27	21.20	23.13	25.05	26.98	28.91		9¼
9½	1.98	3.96	5.94	7.92	9.90	11.88	13.85	15.83	17.81	19.79	21.77	23.75	25.73	27.71	29.69		9½
9¾	2.03	4.06	6.09	8.13	10.16	12.19	14.22	16.25	18.28	20.31	22.34	24.38	26.41	28.44	30.47		9¾
10	2.08	4.17	6.25	8.33	10.42	12.50	14.58	16.67	18.75	20.83	22.92	25.00	27.08	29.17	31.25		10
10¼	2.14	4.27	6.41	8.54	10.68	12.81	14.95	17.08	19.22	21.35	23.49	25.63	27.76	29.90	32.03		10¼
10½	2.19	4.38	6.56	8.75	10.94	13.13	15.31	17.50	19.69	21.88	24.06	26.25	28.44	30.63	32.81		10½
11	2.29	4.58	6.88	9.17	11.46	13.75	16.04	18.33	20.63	22.92	25.21	27.50	29.79	32.08	34.38		11
11½	2.40	4.79	7.19	9.58	11.98	14.38	16.77	19.17	21.56	23.96	26.35	28.75	31.15	33.54	35.94		11½
12	2.50	5.00	7.50	10.00	12.50	15.00	17.5	20.00	22.50	25.00	27.50	30.00	32.50	35.00	37.50	40.00	12
Breadth of Plate (ins.)	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch																

Table of the Weight of Malleable Flat Steel in Lbs. per Lineal Foot.

Breadth of Plate (ins.)	Thickness in Fractions of an Inch.																				Breadth of Plate (ins.)
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	
1	·17	·34	·51	·68	·85	1·02	1·19	1·36	1·53	1·70	1·87	2·04	2·21	2·38	2·55	2·72	2·89	3·06	3·23	3·40	1
1¼	·21	·43	·64	·85	1·06	1·28	1·49	1·70	1·91	2·13	2·34	2·55	2·76	2·98	3·19	3·40	3·61	3·83	4·04	4·25	1¼
1½	·26	·51	·77	1·02	1·28	1·53	1·79	2·04	2·30	2·55	2·81	3·06	3·32	3·57	3·83	4·08	4·34	4·59	4·85	5·10	1½
1¾	·30	·60	·89	1·19	1·49	1·79	2·08	2·38	2·68	2·98	3·27	3·57	3·87	4·17	4·46	4·76	5·06	5·36	5·65	5·95	1¾
2	·34	·68	1·02	1·36	1·70	2·04	2·38	2·72	3·06	3·40	3·74	4·08	4·42	4·76	5·10	5·44	5·78	6·12	6·46	6·80	2
2¼	·38	·77	1·15	1·53	1·91	2·30	2·68	3·06	3·44	3·83	4·21	4·59	4·97	5·36	5·74	6·12	6·50	6·89	7·27	7·65	2¼
2½	·43	·85	1·28	1·70	2·13	2·55	2·98	3·40	3·83	4·25	4·68	5·10	5·53	5·95	6·38	6·80	7·23	7·65	8·08	8·50	2½
2¾	·47	·94	1·40	1·87	2·34	2·81	3·27	3·74	4·21	4·68	5·14	5·61	6·08	6·55	7·01	7·48	7·95	8·42	8·88	9·35	2¾
3	·51	1·02	1·53	2·04	2·55	3·06	3·57	4·08	4·59	5·10	5·61	6·12	6·63	7·14	7·65	8·16	8·67	9·18	9·69	10·20	3
3¼	·55	1·11	1·66	2·21	2·76	3·32	3·87	4·42	4·97	5·53	6·08	6·63	7·18	7·74	8·29	8·84	9·39	9·95	10·50	11·05	3¼
3½	·60	1·19	1·79	2·38	2·98	3·57	4·17	4·76	5·36	5·95	6·55	7·14	7·74	8·33	8·93	9·52	10·12	10·71	11·31	11·90	3½
3¾	·64	1·28	1·91	2·55	3·19	3·83	4·46	5·10	5·74	6·38	7·01	7·65	8·29	8·93	9·56	10·20	10·84	11·48	12·11	12·75	3¾
4	·68	1·36	2·04	2·72	3·40	4·08	4·76	5·44	6·12	6·80	7·48	8·16	8·84	9·52	10·20	10·88	11·56	12·24	12·92	13·60	4
4¼	·72	1·45	2·17	2·89	3·61	4·34	5·06	5·78	6·50	7·23	7·95	8·67	9·39	10·12	10·84	11·56	12·28	13·01	13·73	14·45	4¼
4½	·77	1·53	2·30	3·06	3·83	4·59	5·36	6·12	6·89	7·65	8·42	9·18	9·95	10·71	11·48	12·24	13·01	13·77	14·54	15·30	4½
4¾	·81	1·62	2·42	3·23	4·04	4·85	5·65	6·46	7·27	8·08	8·88	9·69	10·50	11·31	12·11	12·92	13·73	14·54	15·34	16·15	4¾
5	·85	1·70	2·55	3·40	4·25	5·10	5·95	6·80	7·65	8·50	9·35	10·20	11·05	11·90	12·75	13·60	14·45	15·30	16·15	17·00	5
5¼	·89	1·79	2·68	3·57	4·46	5·36	6·25	7·14	8·03	8·93	9·82	10·71	11·60	12·50	13·39	14·28	15·17	16·07	16·96	17·85	5¼
5½	·94	1·87	2·81	3·74	4·68	5·61	6·55	7·48	8·42	9·35	10·29	11·22	12·16	13·09	14·03	14·96	15·90	16·83	17·77	18·70	5½
5¾	·98	1·96	2·93	3·91	4·89	5·87	6·84	7·82	8·80	9·78	10·75	11·73	12·71	13·69	14·66	15·64	16·62	17·60	18·57	19·55	5¾
6	1·02	2·04	3·06	4·08	5·10	6·12	7·14	8·16	9·18	10·20	11·22	12·24	13·26	14·28	15·30	16·32	17·34	18·36	19·38	20·40	6
Breadth of Plate (ins.)	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch.																				

TABLE OF THE WEIGHT OF MALLEABLE FLAT STEEL IN LBS. PER LINEAL FOOT (concluded).

Breadth of Plate (ins.)	Thickness in Fractions of an Inch.																				Breadth of Plate (ins.)
	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	
$6\frac{1}{4}$	1·06	2·13	3·19	4·25	5·31	6·38	7·44	8·50	9·56	10·63	11·69	12·75	13·81	14·88	15·94	17·00	18·06	19·13	20·19	21·25	$6\frac{1}{4}$
$6\frac{1}{2}$	1·11	2·21	3·32	4·42	5·53	6·63	7·74	8·84	9·95	11·05	12·16	13·26	14·37	15·47	16·58	17·68	18·79	19·89	21·00	22·10	$6\frac{1}{2}$
$6\frac{3}{4}$	1·15	2·30	3·44	4·59	5·74	6·89	8·03	9·18	10·33	11·48	12·62	13·77	14·92	16·07	17·21	18·36	19·51	20·66	21·80	22·95	$6\frac{3}{4}$
7	1·19	2·38	3·57	4·76	5·95	7·14	8·33	9·52	10·71	11·90	13·09	14·28	15·47	16·66	17·85	19·04	20·23	21·42	22·61	23·80	7
$7\frac{1}{4}$	1·23	2·47	3·70	4·93	6·16	7·40	8·63	9·86	11·09	12·33	13·56	14·79	16·02	17·26	18·49	19·72	20·95	22·19	23·42	24·65	$7\frac{1}{4}$
$7\frac{1}{2}$	1·28	2·55	3·83	5·10	6·38	7·65	8·93	10·20	11·48	12·75	14·03	15·30	16·58	17·85	19·13	20·40	21·68	22·95	24·23	25·50	$7\frac{1}{2}$
$7\frac{3}{4}$	1·32	2·64	3·95	5·27	6·59	7·91	9·22	10·54	11·86	13·18	14·49	15·81	17·12	18·45	19·76	21·08	22·40	23·72	25·03	26·35	$7\frac{3}{4}$
8	1·36	2·72	4·08	5·44	6·80	8·16	9·52	10·88	12·24	13·60	14·96	16·32	17·68	19·04	20·40	21·76	23·12	24·48	25·84	27·20	8
$8\frac{1}{4}$	1·40	2·81	4·21	5·61	7·01	8·42	9·82	11·22	12·62	14·03	15·43	16·83	18·23	19·64	21·04	22·44	23·84	25·25	26·65	28·05	$8\frac{1}{4}$
$8\frac{1}{2}$	1·45	2·89	4·34	5·78	7·23	8·67	10·12	11·56	13·01	14·45	15·90	17·34	18·79	20·23	21·68	23·12	24·57	26·01	27·46	28·90	$8\frac{1}{2}$
$8\frac{3}{4}$	1·49	2·98	4·46	5·95	7·44	8·93	10·41	11·90	13·39	14·88	16·36	17·85	19·34	20·83	22·31	23·80	25·29	26·78	28·26	29·75	$8\frac{3}{4}$
9	1·53	3·06	4·59	6·12	7·65	9·18	10·71	12·24	13·77	15·30	16·83	18·36	19·89	21·42	22·95	24·48	26·01	27·54	29·07	30·60	9
$9\frac{1}{4}$	1·57	3·15	4·72	6·29	7·86	9·44	11·01	12·58	14·15	15·73	17·30	18·87	20·44	22·02	23·59	25·16	26·73	28·31	29·88	31·45	$9\frac{1}{4}$
$9\frac{1}{2}$	1·62	3·23	4·85	6·46	8·08	9·69	11·31	12·92	14·54	16·15	17·77	19·38	21·00	22·61	24·23	25·84	27·46	29·07	30·69	32·30	$9\frac{1}{2}$
$9\frac{3}{4}$	1·66	3·32	4·97	6·63	8·29	9·95	11·60	13·26	14·92	16·58	18·23	19·89	21·55	23·21	24·86	26·52	28·18	29·84	31·49	33·15	$9\frac{3}{4}$
10	1·70	3·40	5·10	6·80	8·50	10·20	11·90	13·60	15·30	17·00	18·70	20·40	22·10	23·80	25·50	27·20	28·90	30·60	32·30	34·00	10
$10\frac{1}{4}$	1·74	3·49	5·23	6·97	8·71	10·46	12·20	13·94	15·68	17·43	19·17	20·91	22·65	24·40	26·14	27·88	29·62	31·37	33·11	34·85	$10\frac{1}{4}$
$10\frac{1}{2}$	1·79	3·57	5·36	7·14	8·93	10·71	12·50	14·28	16·07	17·85	19·64	21·42	23·21	24·99	26·78	28·56	30·35	32·13	33·92	35·70	$10\frac{1}{2}$
11	1·87	3·74	5·61	7·48	9·35	11·22	13·09	14·96	16·83	18·70	20·57	22·44	24·31	26·18	28·05	29·92	31·79	33·66	35·52	37·40	11
$11\frac{1}{2}$	1·96	3·91	5·87	7·82	9·78	11·73	13·69	15·64	17·60	19·55	21·51	23·46	25·42	27·37	29·33	31·28	33·24	35·19	37·15	39·10	$11\frac{1}{2}$
12	2·04	4·08	6·12	8·16	10·20	12·24	14·28	16·32	18·36	20·40	22·44	24·48	26·52	28·56	30·60	32·64	34·68	36·72	38·76	40·80	12
Breadth of Plate (ins.)	$\frac{1}{20}$	$\frac{2}{20}$	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch.																				

Table of the Weight of Angle and T Steel in Lbs. per Lineal Foot.

Sum of Flanges (ins.)	Thickness in Fractions of an Inch.																	Sum of Flanges (ins.)
	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	
1	·162	·306	·434	·544	·638	—	—	—	—	—	—	—	—	—	—	—	—	1
1¼	·204	·391	·561	·714	·850	—	—	—	—	—	—	—	—	—	—	—	—	1¼
1½	·247	·476	·689	·884	1·063	1·244	—	—	—	—	—	—	—	—	—	—	—	1½
1¾	·289	·561	·816	1·054	1·275	1·479	1·67	—	—	—	—	—	—	—	—	—	—	1¾
2	·332	·646	·944	1·224	1·488	1·734	1·96	—	—	—	—	—	—	—	—	—	—	2
2¼	·374	·731	1·071	1·394	1·700	1·989	2·36	2·52	—	—	—	—	—	—	—	—	—	2¼
2½	·417	·816	1·199	1·564	1·913	2·244	2·56	2·86	—	—	—	—	—	—	—	—	—	2½
2¾	·459	·901	1·326	1·734	2·125	2·499	2·86	3·20	3·52	—	—	—	—	—	—	—	—	2¾
3	·502	·986	1·454	1·904	2·338	2·754	3·15	3·54	3·90	4·25	—	—	—	—	—	—	—	3
3¼	·544	1·071	1·581	2·074	2·550	3·009	3·45	3·88	4·28	4·68	—	—	—	—	—	—	—	3¼
3½	·587	1·156	1·709	2·244	2·763	3·264	3·75	4·22	4·67	5·10	5·52	—	—	—	—	—	—	3½
3¾	·629	1·241	1·836	2·414	2·975	3·519	4·05	4·56	5·05	5·53	5·98	—	—	—	—	—	—	3¾
4	·672	1·326	1·964	2·584	3·188	3·774	4·34	4·90	5·43	5·95	6·45	6·94	—	—	—	—	—	4
4¼	·714	1·411	2·091	2·754	3·400	4·029	4·64	5·24	5·81	6·38	6·92	7·45	7·96	—	—	—	—	4¼
4½	·757	1·496	2·219	2·924	3·613	4·284	4·94	5·58	6·20	6·80	7·39	7·96	8·51	—	—	—	—	4½
4¾	·799	1·581	2·346	3·094	3·825	4·539	5·24	5·92	6·58	7·23	7·85	8·47	9·06	9·64	—	—	—	4¾
5	·842	1·666	2·474	3·264	4·038	4·794	5·53	6·26	6·96	7·65	8·32	8·98	9·61	10·23	10·84	—	—	5
5¼	·884	1·751	2·601	3·434	4·250	5·049	5·83	6·60	7·34	8·08	8·79	9·49	10·17	10·83	11·48	—	—	5¼
5½	·927	1·836	2·729	3·604	4·463	5·304	6·13	6·94	7·73	8·50	9·26	10·00	10·72	11·42	12·11	12·78	—	5½
5¾	·969	1·921	2·856	3·774	4·675	5·559	6·43	7·28	8·11	8·93	9·72	10·51	11·27	12·02	12·75	13·46	14·16	5¾
Sum of Flanges (ins.)	1/20	2/20	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch.																	

TABLE OF THE WEIGHT OF ANGLE AND T STEEL IN LBS. PER LINEAL FOOT (continued).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch.																		Sum of Flanges (ins.)
	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20	
6	2·98	3·94	4·89	5·81	6·72	7·62	8·49	9·35	10·19	11·02	11·82	12·61	13·39	14·14	14·88	—	—	—	6
6¼	3·11	4·11	5·10	6·07	7·02	7·96	8·87	9·78	10·66	11·53	12·38	13·21	14·03	14·82	15·61	—	—	—	6¼
6½	3·24	4·28	5·31	6·32	7·32	8·30	9·26	10·20	11·13	12·04	12·93	13·80	14·66	15·50	16·33	17·14	—	—	6½
6¾	3·37	4·45	5·53	6·58	7·62	8·64	9·64	10·63	11·59	12·55	13·48	14·40	15·30	16·18	17·05	17·90	—	—	6¾
7	3·49	4·62	5·74	6·83	7·91	8·98	10·02	11·05	12·06	13·06	14·03	14·99	15·94	16·86	17·77	18·67	19·54	—	7
7¼	3·62	4·79	5·95	7·09	8·21	9·32	10·40	11·48	12·53	13·57	14·59	15·59	16·58	17·54	18·50	19·43	20·35	—	7¼
7½	3·75	4·96	6·16	7·34	8·51	9·66	10·79	11·90	13·00	14·08	15·14	16·18	17·21	18·22	19·22	20·20	21·16	22·10	7½
7¾	3·88	5·13	6·38	7·60	8·81	10·00	11·17	12·33	13·46	14·59	15·69	16·78	17·85	18·90	19·94	20·96	21·96	22·95	7¾
8	4·00	5·30	6·59	7·85	9·10	10·34	11·55	12·75	13·93	15·10	16·24	17·37	18·49	19·58	20·66	21·73	22·77	23·80	8
8¼	4.13	5·47	6·80	8·11	9·40	10·68	11·93	13·18	14·40	15·61	16·80	17·97	19·13	20·26	21·39	22·49	23·58	24·65	8¼
8½	4·26	5·64	7·01	8·36	9·70	11·02	12·32	13·60	14·87	16·12	17·35	18·56	19·76	20·94	22·11	23·26	24·39	25·50	8½
8¾	4·39	5·81	7·23	8·62	10·00	11·36	12·70	14·03	15·33	16·63	17·90	19·16	20·40	21·62	22·83	24·02	25·19	26·35	8¾
9	4·51	5·98	7·44	8·87	10·29	11·70	13·08	14·45	15·80	17·14	18·45	19·75	21·04	22·30	23·55	24·79	26·00	27·20	9
Sum of Flanges (ins.)	3/20	4/20	5/20	6/20	7/20	8/20	9/20	10/20	11/20	12/20	13/20	14/20	15/20	16/20	17/20	18/20	19/20	20/20	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch.																		

TABLE OF THE WEIGHT OF ANGLE AND T STEEL IN LBS. PER LINEAL FOOT (continued).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch.																		Sum of Flanges (ins.)
	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	
$9\frac{1}{4}$	4·64	6·15	7·65	9·13	10·59	12·04	13·46	14·88	16·27	17·65	19·01	20·35	21·68	22·98	24·28	25·55	26·81	28·05	$9\frac{1}{4}$
$9\frac{1}{2}$	4·77	6·32	7·86	9·38	10·89	12·38	13·85	15·30	16·74	18·16	19·56	20·94	22·31	23·66	25·00	26·32	27·62	28·90	$9\frac{1}{2}$
$9\frac{3}{4}$	4·90	6·49	8·08	9·64	11·19	12·72	14·23	15·73	17·20	18·67	20·11	21·54	22·95	24·34	25·72	27·08	28·42	29·75	$9\frac{3}{4}$
10	5·02	6·66	8·29	9·89	11·48	13·06	14·61	16·15	17·67	19·18	20·66	22·13	23·59	25·02	26·44	27·85	29·23	30·60	10
$10\frac{1}{4}$	5·15	6·83	8·50	10·15	11·78	13·40	14·99	16·58	18·14	19·69	21·22	22·73	24·23	25·70	27·17	28·61	30·04	31·45	$10\frac{1}{4}$
$10\frac{1}{2}$	5·28	7·00	8·71	10·40	12·08	13·74	15·38	17·00	18·61	20·20	21·77	23·32	24·86	26·38	27·89	29·38	30·85	32·30	$10\frac{1}{2}$
$10\frac{3}{4}$	5·41	7·17	8·93	10·66	12·38	14·08	15·76	17·43	19·07	20·71	22·32	23·92	25·50	27·06	28·61	30·14	31·65	33·15	$10\frac{3}{4}$
11	5·53	7·34	9·14	10·91	12·67	14·42	16·14	17·85	19·54	21·22	22·87	24·51	26·14	27·74	29·33	30·91	32·46	34·00	11
$11\frac{1}{4}$	5·66	7·51	9·35	11·17	12·97	14·76	16·52	18·28	20·01	21·73	23·43	25·11	26·78	28·42	30·06	31·67	33·27	34·85	$11\frac{1}{4}$
$11\frac{1}{2}$	5·79	7·68	9·56	11·42	13·27	15·10	16·91	18·70	20·48	22·24	23·98	25·70	27·41	29·10	30·78	32·44	34·08	35·70	$11\frac{1}{2}$
$11\frac{3}{4}$	—	7·85	9·78	11·68	13·57	15·44	17·29	19·13	20·94	22·75	24·53	26·30	28·05	29·78	31·50	33·20	34·88	36·55	$11\frac{3}{4}$
12	—	8·02	9·99	11·93	13·86	15·78	17·67	19·55	21·41	23·26	25·08	26·89	28·69	30·46	32·22	33·97	35·69	37·40	12
$12\frac{1}{4}$	—	8·19	10·20	12·19	14·16	16·12	18·05	19·98	21·88	23·77	25·64	27·49	29·33	31·14	32·95	34·73	36·50	38·25	$12\frac{1}{4}$
Sum of Flanges (ins.)	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch.																		

TABLE OF THE WEIGHT OF ANGLE AND T STEEL IN LBS. PER LINEAL FOOT (concluded).

Sum of Flanges (ins.)	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	Sum of Flanges (ins.)
$12\frac{1}{2}$	—	8·36	10·41	12·44	14·46	16·46	18·44	20·40	22·35	24·28	26·19	28·08	29·96	31·82	33·67	35·50	37·31	39·10	$12\frac{1}{2}$
$12\frac{3}{4}$	—	—	10·63	12·70	14·76	16·80	18·82	20·83	22·81	24·79	26·74	28·68	30·60	32·50	34·39	36·26	38·11	39·95	$12\frac{3}{4}$
13	—	—	10·84	12·95	15·05	17·14	19·20	21·25	23·28	25·30	27·29	29·27	31·24	33·18	35·11	37·03	38·92	40·80	13
$13\frac{1}{4}$	—	—	11·05	13·21	15·35	17·48	19·58	21·68	23·75	25·81	27·85	29·87	31·88	33·86	35·84	37·79	39·73	41·65	$13\frac{1}{4}$
$13\frac{1}{2}$	—	—	11·26	13·46	15·65	17·82	19·97	22·10	24·22	26·32	28·40	30·46	32·51	34·54	36·56	38·56	40·54	42·50	$13\frac{1}{2}$
$13\frac{3}{4}$	—	—	11·48	13·72	15·95	18·16	20·35	22·53	24·68	26·83	28·95	31·06	33·15	35·22	37·28	39·32	41·34	43·35	$13\frac{3}{4}$
14	—	—	—	13·97	16·24	18·50	20·73	22·95	25·15	27·34	29·50	31·65	33·79	35·90	38·00	40·09	42·15	44·20	14
$14\frac{1}{4}$	—	—	—	14·23	16·54	18·84	21·11	23·38	25·62	27·85	30·06	32·25	34·43	36·58	38·73	40·85	42·96	45·05	$14\frac{1}{4}$
$14\frac{1}{2}$	—	—	—	14·48	16·84	19·18	21·50	23·80	26·09	28·36	30·61	32·84	35·06	37·26	39·45	41·62	43·77	45·90	$14\frac{1}{2}$
$14\frac{3}{4}$	—	—	—	14·74	17·14	19·52	21·88	24·23	26·55	28·87	31·16	33·44	35·70	37·94	40·17	42·38	44·57	46·75	$14\frac{3}{4}$
15	—	—	—	—	17·43	19·86	22·26	24·65	27·02	29·38	31·71	34·03	36·34	38·62	40·89	43·15	45·38	47·60	15
Sum of Flanges (ins.)	$\frac{3}{20}$	$\frac{4}{20}$	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{15}{20}$	$\frac{16}{20}$	$\frac{17}{20}$	$\frac{18}{20}$	$\frac{19}{20}$	$\frac{20}{20}$	Sum of Flanges (ins.)

Thickness in Fractions of an Inch.

RULE.—*To Calculate the Weight of Angle Ears:*—
w = weight of metal in lbs. per square foot of t thickness.
t = thickness of angle bar in decimals of a foot.
W = weight of angle bar in lbs. per lineal foot.
S = sum of breadth of flanges in decimals of a foot.
$W = (S - t)w$.

TABLE OF THE WEIGHT OF SHEET METALS OF VARIOUS THICKNESSES IN LBS. PER SQUARE FOOT.

Kind of Metal	Thickness in 16ths of an Inch															
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.
Iron . .	2·5	5·0	7·5	10·0	12·5	15·0	17·5	20·0	22·5	25·0	27·5	30·0	32·5	35·0	37·5	40·0
Steel .	2·55	5·10	7·65	10·20	12·75	15·30	17·85	20·40	22·95	25·50	28·05	30·60	33·15	35·70	38·25	40·80
Brass .	2·78	5·50	8·33	11·10	13·88	16·65	19·43	22·20	24·98	27·75	30·53	33·30	36·08	38·85	41·63	44·4
Copper .	2·86	5·72	8·58	11·44	14·30	17·16	20·02	22·88	25·73	28·59	31·45	34·31	37·17	40·03	42·89	45·75
Lead .	3·71	7·42	11·13	14·84	18·55	22·27	25·98	29·69	33·40	37·11	40·82	44·53	48·24	51·95	55·66	59·38
Zinc . .	2·37	4·75	7·12	9·49	11·87	14·24	16·61	18·99	21·36	23·73	26·11	28·48	30·85	33·23	35·60	37·98

Kind of Metal	Thicknesses by the Birmingham Wire Gauge															
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12	No. 13	No. 14	No. 15	No. 16
Iron . .	12·00	11·36	10·36	9·52	8·80	8·12	7·20	6·60	5·92	5·36	4·80	4·36	3·80	3·32	2·88	2·60
Steel .	12·24	11·59	10·57	9·71	8·98	8·28	7·34	6·73	6·04	5·47	4·90	4·44	3·88	3·39	2·94	2·65
Brass .	13·32	12·61	11·50	10·57	9·77	9·01	7·99	7·33	6·57	5·95	5·32	4·84	4·22	3·68	3·20	2·89
Copper .	13·73	12·99	11·85	10·89	10·07	9·29	8·24	7·55	6·77	6·13	5·49	4·99	4·35	3·80	3·29	2·97
Lead .	17·81	16·86	15·38	14·13	13·06	12·05	10·69	9·80	8·79	7·96	7·13	6·47	5·64	4·93	4·28	3·86
Zinc . .	11·39	10·78	9·84	9·04	8·36	7·71	6·84	6·27	5·62	5·09	4·56	4·14	3·61	3·15	2·73	2·47

Kind of Metal	Thicknesses by the Birmingham Wire Gauge															
	No. 17	No. 18	No. 19	No. 20	No. 21	No. 22	No. 23	No. 24	No. 25	No. 26	No. 27	No. 28	No. 29	No. 30	No. 31	No. 32
Iron . .	2·32	1·96	1·68	1·40	1·28	1·12	1·00	·88	·80	·72	·64	·56	·52	·48	·40	·36
Steel .	2·37	2·00	1·71	1·43	1·31	1·14	1·02	·90	·82	·73	·65	·57	·53	·49	·41	·37
Brass .	2·58	2·18	1·86	1·55	1·42	1·24	1·11	·98	·89	·80	·71	·62	·58	·53	·44	·40
Copper .	2·65	2·24	1·92	1·60	1·46	1·28	1·14	1·01	·92	·82	·73	·64	·59	·55	·46	·41
Lead .	3·44	2·91	2·49	2·08	1·90	1·66	1·48	1·31	1·19	1·07	·95	·83	·77	·71	·59	·53
Zinc . .	2·20	1·86	1·59	1·33	1·22	1·06	·95	·84	·76	·68	·61	·53	·49	·46	·38	·34

TABLE OF THE WEIGHT OF ANGLE IRON IN LBS. PER LINEAL FOOT.

Sum of Flanges (ins.)	Thickness in Fractions of an Inch															Sum of Flanges (ins.)
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	
1	·20	·37	·51	·63	·72	—	—	—	—	—	—	—	—	—	—	1
1¼	·25	·47	·66	·83	·98	—	—	—	—	—	—	—	—	—	—	1¼
1½	·30	·57	·82	1·04	1·24	1·41	—	—	—	—	—	—	—	—	—	1½
1¾	·35	·68	·98	1·25	1·50	1·72	—	—	—	—	—	—	—	—	—	1¾
2	·40	·78	1·13	1·46	1·76	2·03	2·28	—	—	—	—	—	—	—	—	2
2¼	·46	·89	1·29	1·67	2·02	2·34	2·64	—	—	—	—	—	—	—	—	2¼
2½	·51	·99	1·45	1·88	2·28	2·66	3·01	3·33	—	—	—	—	—	—	—	2½
2¾	·56	1·09	1·60	2·08	2·54	2·97	3·37	3·75	—	—	—	—	—	—	—	2¾
3	—	1·20	1·76	2·29	2·80	3·28	3·74	4·17	4·57	—	—	—	—	—	—	3
3¼	—	1·30	1·91	2·50	3·06	3·59	4·10	4·58	5·03	—	—	—	—	—	—	3¼
3½	—	1·41	2·07	2·71	3·32	3·91	4·47	5·00	5·51	5·99	—	—	—	—	—	3½
3¾	—	1·51	2·23	2·92	3·58	4·22	4·83	5·42	5·98	6·51	—	—	—	—	—	3¾
4	—	1·62	2·38	3·13	3·84	4·53	5·20	5·83	6·45	7·03	7·59	—	—	—	—	4
4¼	—	1·72	2·54	3·33	4·10	4·84	5·56	6·25	6·91	7·55	8·16	—	—	—	—	4¼
4½	—	1·82	2·70	3·54	4·36	5·16	5·92	6·67	7·38	8·07	8·74	9·38	—	—	—	4½
4¾	—	1·93	2·85	3·75	4·62	5·47	6·29	7·08	7·85	8·59	9·31	10·00	—	—	—	4¾
5	—	2·03	3·01	3·96	4·88	5·78	6·65	7·50	8·32	9·11	9·88	10·63	11·34	—	—	5
5¼	—	2·14	3·16	4·17	5·14	6·09	7·02	7·92	8·79	9·64	10·46	11·25	12·02	—	—	5¼
5½	—	2·24	3·32	4·38	5·40	6·41	7·38	8·33	9·26	10·16	11·03	11·88	12·69	13·49	—	5½
5¾	—	2·34	3·48	4·58	5·66	6·72	7·75	8·75	9·73	10·68	11·60	12·50	13·37	14·22	—	5¾
6	—	2·45	3·63	4·79	5·92	7·03	8·11	9·17	10·20	11·20	12·17	13·13	14·05	14·95	15·82	6
Sum of Flanges (ins.)	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch															

TABLE OF THE WEIGHT OF ANGLE IRON IN LBS. PER LINEAL FOOT (continued).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch															Sum of Flanges (ins.)
	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	1 1/16	
6¼	3·79	5·00	6·18	7·34	8·48	9·58	10·66	11·72	12·75	13·75	14·72	15·68	—	—	—	6¼
6½	3·95	5·21	6·45	7·66	8·84	10·00	11·13	12·24	13·32	14·38	15·40	16·41	—	—	—	6½
6¾	4·10	5·42	6·71	7·97	9·21	10·42	11·60	12·76	13·89	15·00	16·08	17·14	—	—	—	6¾
7	4·26	5·63	6·97	8·28	9·57	10·83	12·07	13·28	14·46	15·63	16·76	17·86	18·95	20·00	—	7
7¼	4·41	5·83	7·23	8·59	9·93	11·25	12·54	13·80	15·04	16·25	17·43	18·59	19·73	20·83	—	7¼
7½	4·57	6·04	7·49	8·91	10·30	11·67	13·01	14·32	15·61	16·88	18·11	19·32	20·51	21·67	—	7½
7¾	4·73	6·25	7·75	9·22	10·66	12·08	13·48	14·84	16·18	17·50	18·79	20·05	21·29	22·50	—	7¾
8	4·88	6·46	8·01	9·53	11·03	12·50	13·95	15·36	16·76	18·13	19·47	20·78	22·07	23·33	24·57	8
8¼	5·04	6·67	8·27	9·84	11·39	12·92	14·44	15·89	17·33	18·75	20·14	21·51	22·85	24·17	25·46	8¼
8½	5·20	6·88	8·53	10·16	11·76	13·33	14·88	16·41	17·90	19·38	20·82	22·24	23·63	25·00	26·34	8½
8¾	5·35	7·08	8·79	10·47	12·12	13·75	15·35	16·93	18·48	20·00	21·50	22·97	24·41	25·83	27·23	8¾
9	5·51	7·29	9·05	10·78	12·49	14·17	15·82	17·45	19·05	20·63	22·17	23·70	25·20	26·67	28·11	9
9¼	5·66	7·50	9·31	11·09	12·85	14·58	16·29	17·97	19·62	21·25	22·85	24·43	25·98	27·50	29·00	9¼
9½	5·82	7·71	9·57	11·41	13·22	15·00	16·76	18·49	20·20	21·88	23·53	25·16	26·76	28·33	29·88	9½
9¾	5·98	7·92	9·83	11·72	13·58	15·42	17·23	19·01	20·77	22·50	24·21	25·89	27·54	29·17	30·77	9¾
10	6·13	8·13	10·09	12·03	13·95	15·83	17·70	19·53	21·34	23·13	24·88	26·61	28·32	30·00	31·65	10
10¼	—	8·33	10·35	12·34	14·31	16·25	18·16	20·05	21·91	23·75	25·56	27·34	29·10	30·83	32·54	10¼
10½	—	8·54	10·61	12·66	14·67	16·67	18·63	20·57	22·49	24·38	26·24	28·07	29·88	31·67	33·42	10½
10¾	—	8·75	10·87	12·97	15·04	17·08	19·10	21·09	23·06	25·00	26·91	28·80	30·66	32·50	34·31	10¾
11	—	8·96	11·13	13·28	15·40	17·50	19·51	21·61	23·63	25·63	27·59	29·53	31·45	33·33	35·20	11
11¼	—	9·17	11·39	13·59	15·77	17·92	20·04	22·14	24·21	26·25	28·27	30·26	32·23	34·17	36·08	11¼
Sum of Flanges (ins.)	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	1 1/16	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch															

Table of the Weight of Angle Iron in Lbs. per Lineal Foot (concluded).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch															Sum of Flanges (ins.)
	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	
$11\frac{1}{2}$	13·91	16·13	18·33	20·51	22·66	24·78	26·88	29·85	30·99	33·01	35·00	36·97	38·91	40·82	42·71	$11\frac{1}{2}$
$11\frac{3}{4}$	14·22	16·50	18·75	20·98	23·18	25·35	27·50	29·62	31·72	33·79	35·83	37·85	39·84	41·81	43·75	$11\frac{3}{4}$
12	14·53	16·86	19·17	21·45	23·70	25·92	28·13	30·30	32·45	34·57	36·67	38·74	40·78	42·80	44·79	12
$12\frac{1}{4}$	14·84	17·23	19·58	21·91	24·22	26·50	28·75	30·98	33·18	35·35	37·50	39·62	41·72	43·79	45·83	$12\frac{1}{4}$
$12\frac{1}{2}$	15·16	17·59	20·00	22·38	24·74	27·07	29·38	31·65	33·91	36·13	28·33	40·51	42·66	44·78	46·88	$12\frac{1}{2}$
$12\frac{3}{4}$	15·47	17·96	20·42	22·85	25·26	27·64	30·00	32·33	34·64	36·91	39·17	41·39	43·59	45·77	47·92	$12\frac{3}{4}$
13	15·78	18·32	20·83	23·32	25·78	28·22	30·63	33·01	35·36	37·70	40·00	42·28	44·53	46·76	48·96	13
$13\frac{1}{4}$	16·09	18·68	21·25	23·79	26·30	28·79	31·25	33·68	36·09	38·48	40·83	43·16	45·47	47·75	50·00	$13\frac{1}{4}$
$13\frac{1}{2}$	16·41	19·05	21·67	24·26	26·82	29·36	31·88	34·36	36·82	39·26	41·67	44·05	36·41	48·74	51·04	$13\frac{1}{2}$
$13\frac{3}{4}$	16·72	19·41	22·08	24·73	27·34	29·93	32·50	35·04	37·55	40·04	42·50	44·93	47·34	49·73	52·08	$13\frac{3}{4}$
14	17·03	19·78	22·50	25·20	27·86	30·51	33·13	35·72	38·28	40·82	43·33	45·82	48·28	50·72	53·13	14
$14\frac{1}{4}$	17·34	20·14	22·92	25·66	28·39	31·08	33·75	36·39	39·01	41·60	44·17	46·71	49·22	51·71	54·17	$14\frac{1}{4}$
$14\frac{1}{2}$	17·66	20·51	23·33	26·13	28·91	31·65	34·38	37·07	39·74	42·38	45·00	47·59	50·16	52·70	55·21	$14\frac{1}{2}$
$14\frac{3}{4}$	17·97	20·87	23·75	26·60	29·43	32·23	35·00	37·75	40·47	43·16	45·83	48·48	51·09	53·68	56·25	$14\frac{3}{4}$
15	18·28	21·24	24·17	27·07	29·95	32·80	35·63	38·43	41·20	43·95	46·67	49·36	52·03	54·67	57·29	15
$15\frac{1}{4}$	18·59	21·60	24·58	27·54	30·47	33·37	36·25	39·10	41·93	44·73	47·50	50·25	52·97	55·66	58·32	$15\frac{1}{4}$
$15\frac{1}{2}$	18·91	21·97	25·00	28·01	30·99	33·95	36·88	30·78	42·66	45·51	48·33	51·13	53·91	56·65	59·38	$15\frac{1}{2}$
$15\frac{3}{4}$	19·22	22·33	25·42	28·48	31·51	34·52	37·50	40·46	43·39	46·29	49·17	52·02	54·84	57·64	60·42	$15\frac{3}{4}$
16	19·53	22·70	25·83	28·95	32·03	35·09	38·13	41·13	44·11	47·07	50·00	52·90	55·78	58·63	61·46	16
Sum of Flanges (ins.)	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	$1\frac{1}{16}$	$1\frac{1}{8}$	$1\frac{3}{16}$	$1\frac{1}{4}$	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch															

LE ROUND AND SQUARE
EAL FOOT.

…s.	Width in Ins.	Weight in Lbs.	
…re		Round	Square
75	8	167·53	[illegible]
52	[illegible]	172·81	220·05
	[illegible]	178·17	[illegible]
33	[illegible]	183·61	233·80
19	[illegible]	189·13	240·83
08	[illegible]	194·73	247·97
02	[illegible]	200·42	255·21
00	[illegible]	206·19	262·55
02			
08	9	212·04	270·00
19	[illegible]	217·97	277·55
	[illegible]	223·98	285·21
33	[illegible]	230·07	292·97
52	[illegible]	236·25	300·83
75	[illegible]	242·51	308·80
02	[illegible]	248·85	316·88
3	[illegible]	255·27	325·05
7			
1	10	261·77	333·33
[illegible]	[illegible]	268·36	341·72
	[illegible]	275·03	350·21
0	[illegible]	281·77	358·80
5	[illegible]	288·60	367·50
1	[illegible]	295·52	376·30
7	[illegible]	302·51	385·21
3	[illegible]	309·59	394·22
0			
3	11	316·75	403·33
5	[illegible]	323·99	412·55
	[illegible]	331·31	421·88
3	[illegible]	338·71	431·30
9	[illegible]	346·20	440·83
1	[illegible]	353·76	450·47
)	[illegible]	361·41	460·21
)	[illegible]	369·14	470·05
)			
1	12	376·95	480·00
2			
…e	Width in Ins.	Round	Square
		Weight in Lbs.	

TABLE OF THE WEIGHT OF THE BUTTERLY COMPANY'S PATENT SOLID WROUGHT-IRON DECK-BEAMS.

No. of Section	Depth of Beam (ins.)	Width of Top Flange (ins.)	Width of Bulb (ins.)	Average Weight per Lineal Foot (lbs.)	No. of Section	Depth of Beam (ins.)	Width of Top Flange (ins.)	Width of Bulb (ins.)	Average Weight per Lineal Foot (lbs.)
1	16	6¼	3¼	53 to 56	11	—	—	—	—
2	15	6¼	3¼	52 „ 55	12	8	5¼	1⅞	27 to 28
3	14	6¼	3¼	50 „ 54	13	7	5	1¾	22 „ 25
4	13	6¼	3¼	49 „ 53	14	—	—	—	—
5	12	6¼	3¼	47 „ 50	15	6	5	1½	19 to 20
6	11	6½	2¼	43 „ 44	16	—	—	—	—
7	10	6	2⅛	35 „ 37	17	5	4	1½	14½ to 16
8	—	—	—	—	18	4	3	1	9½
9	9	6¼	3¼	42 to 45	19*	6½	3½	15/16	16 to 17
10	9	5½	2	31 „ 33	20*	5	2½	15/16	11½ „ 12

* These two are bulb angle-iron; all the others are bulb T-irons.

TABLE OF THE WEIGHT OF SOLID WROUGHT-IRON BULB-PLATE BEAMS.

Depth of Beam (ins.)	Thickness of Web (ins.)	Width of Bulb (ins.)	Weight per Lineal Foot (lbs.)	Depth of Beam (ins.)	Thickness of Web (ins.)	Width of Bulb (ins.)	Weight per Lineal Foot (lbs.)	Depth of Beam (ins.)	Thickness of Web (ins.)	Width of Bulb (ins.)	Weight per Lineal Foot (lbs.)
12	¾	2⅝	39·20	9	7/16	1 9/16	16·64	7	5/16	1⅛	9·02
„	⅝	2 3/16	31·40	„	⅜	1 5/16	13·55	„	¼	⅞	6·85
„	½	1¾	24·09	„	5/16	1⅛	11·21	6	½	1¾	14·1
11	¾	2⅝	36·70	„	¼	⅞	8·52	„	7/16	1 9/16	12·06
„	⅝	2 3/16	29·32	8	½	1¾	17·42	„	⅜	1 5/16	9·80
„	½	1¾	22·42	„	7/16	1 9/16	14·98	„	5/16	1⅛	7·98
10	⅝	2 3/16	24·92	„	⅜	1 5/16	12·30	„	¼	⅞	6·02
„	9/16	1 13/16	23·70	„	5/16	1⅛	10·06	5	½	1¾	12·42
„	½	1¾	20·76	„	¼	⅞	7·69	„	7/16	1 9/16	10·60
„	7/16	1 9/16	17·54	7	½	1¾	15·76	„	⅜	1 5/16	8·55
„	⅜	1 5/16	14·80	„	7/16	1 9/16	13·52	„	5/16	1⅛	6·94
9	½	1¾	19·09	„	⅜	1 5/16	11·05	„	¼	⅞	5·19

TABLE OF THE WEIGHT OF DECK CAULKING IN LBS. PER FOOT RUN.

Thickness of plank (ins.) . .	7	6	5	4	3	2½	2	1½
Size of seam (ins.)	7/16	7/16	⅜	5/16	¼	3/16	⅛	1/16
Weight per foot run . . .	·70	·60	·50	·40	·30	·25	·18	·10

TABLE GIVING WEIGHTS OF GIRDER AND BEAM IRON, AS FURNISHED BY MESSRS. JOHN WALLACE AND CO., OF LONDON AND DUNDEE.

Maker's No. of Plate	Maker's No. of Section	Depth of Web in Ins.	Thickness of Web in Ins.	Width of Flanges in Ins.	Weight per Foot in Lbs.	Maker's No. of Plate	Maker's No. of Section	Depth of Web in Ins.	Thickness of Web in Ins.	Width of Flanges in Ins.	Weight per Foot in Lbs.
GIRDER IRON											
1	62	20	¾	7	90	21	57a	8	⅝	6⅛	38
1	62a	20	⅞	7⅛	100	22	14	8	7/16	5	29
2	63	19	¾	6⅞	88	22	14a	8	⅝	5¼	35
2	63a	19	⅞	7	97	22	15	8	⅜	4	22
3	64	18	⅝	6⅝	77	22	15a	8	½	4⅛	25
3	64a	18	¾	6¾	86	23	6	8	5/16	2¾	15
4	65	17	⅝	6¼	70	23	6a	8	7/16	2⅝	18
4	65a	17	¾	6⅜	77	24	31	7	⅜	4	20
5	54	16	9/16	5½	58	24	31a	7	9/16	4¼	25
5	54a	16	¾	5¾	70	24	13	7⅛	5/16	3¾	18
6	53	15	½	5	50	24	13a	7⅛	½	3¾	22
6	53a	15	⅝	5⅜	60	23	5	7	⅜	2¼	12
7	29	14	9/16	5⅛	55	23	5a	7	7/16	2⅝	15
7	29a	14	¾	5⅜	65	25	12	6¼	9/16	3⅛	16
8	55	12⅝	9/16	5¼	45	25	12a	6¼	½	3¼	20
8	55a	12⅝	¾	5⅛	53	20	4	6¼	5/16	2⅝	11
9	27	12	⅝	7⅜	80	20	4a	6¼	7/16	2¼	14
10	27a	12	1	7½	85	25	19	6	7/16	5	25
11	26	12	9/16	6	55	25	19a	6	⅜	5¼	30
11	26a	12	¾	6½	65	26	60	6	⅜	4	19
12	10	12	7/16	5	40	26	60a	6	⅜	4⅛	22
12	10a	12	¾	5½	50	26	30	6	5/16	3	14
13	58	11	7/16	5	36	26	30a	6	7/16	3⅛	18
13	58a	11	⅝	5½	43	17	16	5½	5/16	2¾	12
14	25	10	7/16	5	35	17	16a	5½	½	3	15
14	25a	10	¾	5¼	45	18	3	5½	½	2	10
15	9	10	7/16	4½	30	18	3a	5½	⅜	2⅛	12
15	9a	10	⅝	4¾	40	16	18	5	⅜	4½	22
16	23	9½	⅝	4½	27	16	18a	5	⅜	4⅝	25
16	23a	9½	½	4⅝	32	19	17	5	½	3	12
17	8	9¼	⅝	3¾	22	19	17a	5	7/16	3⅛	15
17	8a	9¼	⅝	4	30	15	2	4¾	½	2	8
18	11	9¼	⅜	3½	20	15	2a	4¾	⅜	2⅛	10
18	11a	9¼	½	3⅝	24	14	52	4	½	3	11
21	59	9	⅝	6	39	14	52a	4	⅜	3⅛	13
19	56	9	⅜	4	26	12	1	4	5/16	2	7
19	56a	9	½	4⅛	29	12	1a	4	5/16	2⅛	9
20	7	8¾	⅜	2⅝	18	13	0	3⅛	3/16	2	6½
20	7a	8¾	½	2¾	22	13	0a	3⅛	5/16	2⅛	8
21	57	8	½	6	35	11	24	3	¼	3	9
BEAM IRON											
32	75	12	9/16	6	49	34	44a	7	½	4⅝	24
32	74	10½	½	5⅝	36	34	43	6	⅜	4⅛	18
33	73	9	½	5⅝	30	34	43a	6	½	4¼	22
33	72	8	⅜	5⅝	25	35	42	5	5/16	3½	12
33	71	7	⅜	5⅛	22	35	42a	5	7/16	3⅝	16½
33	70	6	5/16	4¾	16	35	41	4	5/16	3	9
34	44	7	⅜	4½	20	35	41a	4	7/16	3½	16½

TABLE OF THE WEIGHT OF MALLEABLE FLAT STEEL IN LBS. PER LINEAL FOOT.

Breadth of Plate (ins.)	Thickness in Fractions of an Inch																Breadth of Plate (ins.)
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	
1	·21	·43	·64	·85	1·06	1·28	1·49	1·70	1·91	2·13	2·34	2·55	2·76	2·98	3·19	3·40	1
$1\frac{1}{4}$	·27	·53	·80	1·06	1·33	1·59	1·86	2·13	2·39	2·66	2·92	3·19	3·45	3·72	3·98	4·25	$1\frac{1}{4}$
$1\frac{1}{2}$	·32	·64	·96	1·28	1·59	1·91	2·23	2·55	2·87	3·19	3·51	3·83	4·14	4·46	4·78	5·10	$1\frac{1}{2}$
$1\frac{3}{4}$	·37	·74	1·12	1·49	1·86	2·23	2·60	2·98	3·35	3·72	4·09	4·46	4·83	5·21	5·58	5·95	$1\frac{3}{4}$
2	·43	·85	1·28	1·70	2·13	2·55	2·98	3·40	3·83	4·25	4·68	5·10	5·53	5·95	6·38	6·80	2
$2\frac{1}{4}$	·48	·96	1·43	1·91	2·39	2·87	3·35	3·82	4·30	4·78	5·26	5·74	6·22	6·69	7·17	7·65	$2\frac{1}{4}$
$2\frac{1}{2}$	·53	1·06	1·59	2·13	2·66	3·19	3·72	4·25	4·78	5·31	5·84	6·38	6·91	7·44	7·97	8·50	$2\frac{1}{2}$
$2\frac{3}{4}$	·58	1·17	1·75	2·34	2·92	3·51	4·09	4·68	5·26	5·84	6·43	7·01	7·60	8·18	8·77	9·35	$2\frac{3}{4}$
3	·64	1·28	1·91	2·55	3·19	3·83	4·46	5·10	5·74	6·38	7·01	7·65	8·29	8·93	9·56	10·20	3
$3\frac{1}{4}$	·69	1·38	2·07	2·76	3·45	4·14	4·83	5·53	6·22	6·91	7·60	8·29	8·98	9·67	10·36	11·05	$3\frac{1}{4}$
$3\frac{1}{2}$	·74	1·49	2·23	2·98	3·72	4·46	5·21	5·95	6·69	7·44	8·18	8·93	9·67	10·41	11·16	11·90	$3\frac{1}{2}$
$3\frac{3}{4}$	·80	1·59	2·39	3·19	3·98	4·78	5·58	6·38	7·17	7·97	8·77	9·56	10·36	11·16	11·95	12·75	$3\frac{3}{4}$
4	·85	1·70	2·55	3·40	4·25	5·10	5·95	6·80	7·65	8·50	9·35	10·20	11·05	11·90	12·75	13·60	4
$4\frac{1}{4}$	·90	1·81	2·71	3·61	4·52	5·42	6·32	7·22	8·13	9·03	9·93	10·84	11·74	12·64	13·55	14·45	$4\frac{1}{4}$
$4\frac{1}{2}$	·96	1·91	2·87	3·83	4·78	5·74	6·69	7·65	8·61	9·56	10·52	11·48	12·43	13·39	14·34	15·30	$4\frac{1}{2}$
$4\frac{3}{4}$	1·01	2·02	3·03	4·04	5·05	6·06	7·07	8·08	9·08	10·09	11·10	12·11	13·12	14·13	15·14	16·15	$4\frac{3}{4}$
5	1·06	2·13	3·19	4·25	5·31	6·38	7·44	8·50	9·56	10·63	11·69	12·75	13·81	14·88	15·94	17·00	5
$5\frac{1}{4}$	1·12	2·23	3·35	4·46	5·58	6·69	7·81	8·93	10·04	11·16	12·27	13·39	14·50	15·62	16·73	17·85	$5\frac{1}{4}$
$5\frac{1}{2}$	1·17	2·34	3·51	4·68	5·84	7·01	8·18	9·35	10·52	11·69	12·86	14·03	15·19	16·36	17·53	18·70	$5\frac{1}{2}$
$5\frac{3}{4}$	1·22	2·44	3·67	4·89	6·11	7·33	8·55	9·78	11·00	12·22	13·44	14·66	15·88	17·11	18·33	19·55	$5\frac{3}{4}$
6	1·28	2·55	3·83	5·10	6·38	7·65	8·93	10·20	11·48	12·75	14·03	15·30	16·58	17·85	19·13	20·40	6
Breadth of Plate (ins.)	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch																

TABLE OF THE WEIGHT OF MALLEABLE FLAT STEEL IN LBS. PER LINEAL FOOT (concluded).

Breadth of Plate (ins.)	Thickness in Fractions of an Inch																Breadth of Plate (ins.)
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	
6¼	1·33	2·66	3·98	5·31	6·64	7·97	9·30	10·63	11·95	13·28	14·61	15·94	17·27	18·59	19·92	21·25	6¼
6½	1·38	2·76	4·14	5·53	6·91	8·29	9·67	11·05	12·43	13·81	15·19	16·58	17·96	19·34	20·72	22·10	6½
6¾	1·43	2·87	4·30	5·74	7·17	8·61	10·04	11·48	12·91	14·34	15·78	17·21	18·65	20·08	21·52	22·95	6¾
7	1·49	2·98	4·46	5·95	7·44	8·93	10·41	11·90	13·39	14·88	16·36	17·85	19·34	20·83	22·31	23·80	7
7¼	1·54	3·08	4·62	6·16	7·70	9·24	10·78	12·33	13·87	15·41	16·95	18·49	20·03	21·57	23·11	24·65	7¼
7½	1·59	3·19	4·78	6·38	7·97	9·56	11·16	12·75	14·34	15·94	17·53	19·13	20·72	22·31	23·91	25·50	7½
7¾	1·65	3·29	4·94	6·59	8·23	9·88	11·53	13·18	14·82	16·47	18·12	19·76	21·41	23·06	24·70	26·35	7¾
8	1·70	3·40	5·10	6·80	8·50	10·20	11·90	13·60	15·30	17·00	18·70	20·40	22·10	23·80	25·50	27·20	8
8¼	1·75	3·51	5·26	7·01	8·77	10·52	12·27	14·03	15·78	17·53	19·28	21·04	22·79	24·54	26·30	28·05	8¼
8½	1·81	3·61	5·42	7·23	9·03	10·84	12·64	14·45	16·26	18·06	19·87	21·68	23·48	25·29	27·09	28·90	8½
8¾	1·86	3·72	5·58	7·44	9·30	11·16	13·02	14·88	16·73	18·59	20·45	22·31	24·17	26·03	27·89	29·75	8¾
9	1·91	3·83	5·74	7·65	9·56	11·48	13·39	15·30	17·21	19·13	21·04	22·95	24·86	26·78	28·69	30·60	9
9¼	1·97	3·93	5·90	7·86	9·83	11·79	13·76	15·73	17·69	19·66	21·62	23·59	25·55	27·52	29·48	31·45	9¼
9½	2·02	4·04	6·06	8·08	10·09	12·11	14·13	16·16	18·17	20·19	22·21	24·23	26·24	28·26	30·28	32·30	9½
9¾	2·07	4·14	6·22	8·29	10·36	12·43	14·50	16·58	18·64	20·72	22·79	24·86	26·93	29·01	31·08	33·15	9¾
10	2·13	4·25	6·38	8·50	10·63	12·75	14·88	17·00	19·13	21·25	23·38	25·50	27·63	29·75	31·88	34·00	10
10¼	2·18	4·36	6·53	8·71	10·89	13·07	15·25	17·43	19·60	21·78	23·96	26·14	28·32	30·49	32·67	34·85	10¼
10½	2·23	4·46	6·69	8·93	11·16	13·39	15·62	17·85	20·08	22·31	24·54	26·78	29·01	31·24	33·47	35·70	10½
11	2·34	4·68	7·01	9·35	11·69	14·03	16·36	18·70	21·04	23·38	25·71	28·05	30·39	32·73	35·06	37·40	11
11½	2·44	4·89	7·33	9·78	12·22	14·66	17·11	19·55	21·99	24·44	26·88	29·33	31·77	34·21	36·66	39·10	11½
12	2·55	5·10	7·65	10·20	12·75	15·30	17·85	20·40	22·95	25·50	28·05	30·60	33·15	35·70	38·25	40·80	12
Breadth of Plate (ins.)	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	1 in.	Breadth of Plate (ins.)
	Thickness in Fractions of an Inch																

TABLE OF THE WEIGHT OF ANGLE STEEL IN LBS. PER LINEAL FOOT.

Sum of Flanges (ins.)	Thickness in Fractions of an Inch														Sum of Flanges (ins.)
	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	
1	·199	·372	·518	·638	—	—	—	—	—	—	—	—	—	—	1
$1\frac{1}{4}$	·252	·478	·677	·850	—	—	—	—	—	—	—	—	—	—	$1\frac{1}{4}$
$1\frac{1}{2}$	·305	·584	·837	1·063	1·26	—	—	—	—	—	—	—	—	—	$1\frac{1}{2}$
$1\frac{3}{4}$	·359	·691	·996	1·275	1·53	—	—	—	—	—	—	—	—	—	$1\frac{3}{4}$
2	·412	·797	1·155	1·488	1·79	2·07	—	—	—	—	—	—	—	—	2
$2\frac{1}{4}$	·465	·903	1·315	1·700	2·06	2·39	—	—	—	—	—	—	—	—	$2\frac{1}{4}$
$2\frac{1}{2}$	·518	1·009	1·474	1·913	2·32	2·71	3·07	—	—	—	—	—	—	—	$2\frac{1}{2}$
$2\frac{3}{4}$	·571	1·116	1·634	2·125	2·59	3·03	3·44	—	—	—	—	—	—	—	$2\frac{3}{4}$
3	·624	1·222	1·793	2·338	2·86	3·35	3·81	4·25	—	—	—	—	—	—	3
$3\frac{1}{4}$	·677	1·328	1·952	2·550	3·12	3·67	4·18	4·68	—	—	—	—	—	—	$3\frac{1}{4}$
$3\frac{1}{2}$	·730	1·434	2·112	2·763	3·39	3·98	4·56	5·10	5·62	—	—	—	—	—	$3\frac{1}{2}$
$3\frac{3}{4}$	·784	1·541	2·271	2·975	3·65	4·30	4·93	5·53	6·10	—	—	—	—	—	$3\frac{3}{4}$
4	·837	1·647	2·430	3·188	3·92	4·62	5·30	5·95	6·57	7·17	—	—	—	—	4
$4\frac{1}{4}$	·890	1·753	2·590	3·400	4·18	4·94	5·67	6·38	7·05	7·70	—	—	—	—	$4\frac{1}{4}$
$4\frac{1}{2}$	·943	1·859	2·749	3·613	4·45	5·26	6·04	6·80	7·53	8·23	8·91	—	—	—	$4\frac{1}{2}$
$4\frac{3}{4}$	·996	1·966	2·909	3·825	4·71	5·58	6·41	7·23	8·01	8·77	9·50	—	—	—	$4\frac{3}{4}$
5	1·049	2·072	3·068	4·038	4·98	5·90	6·79	7·65	8·49	9·30	10·08	10·84	—	—	5
$5\frac{1}{4}$	1·102	2·178	3·228	4·250	5·25	6·22	7·16	8·08	8·96	9·83	10·66	11·48	12·26	—	$5\frac{1}{4}$
$5\frac{1}{2}$	1·155	2·284	3·388	4·463	5·51	6·53	7·53	8·50	9·44	10·36	11·25	12·11	12·95	13·76	$5\frac{1}{2}$
$5\frac{3}{4}$	1·209	2·391	3·546	4·675	5·78	6·85	7·90	8·93	9·92	10·89	11·83	12·75	13·64	14·50	$5\frac{3}{4}$
Sum of Flanges (ins.)	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch														

Table of the Weight of Angle Steel in Lbs. per Lineal Foot (continued).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch														Sum of Flanges (ins.)
	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	
6	3·71	4·89	6·04	7·17	8·27	9·35	10·40	11·42	12·42	13·39	14·33	15·25	—	—	6
$6\frac{1}{4}$	3·86	5·10	6·31	7·49	8·65	9·78	10·88	11·95	13·00	14·03	15·02	15·99	—	—	$6\frac{1}{4}$
$6\frac{1}{2}$	4·02	5·31	6·57	7·81	9·02	10·20	11·36	12·48	13·59	14·66	15·71	16·73	—	—	$6\frac{1}{2}$
$6\frac{3}{4}$	4·18	5·53	6·84	8·13	9·39	10·63	11·83	13·02	14·17	15·30	16·40	17·48	—	—	$6\frac{3}{4}$
7	4·34	5·74	7·11	8·45	9·76	11·05	12·31	13·55	14·76	15·94	17·09	18·22	19·32	—	7
$7\frac{1}{4}$	4·50	5·95	7·37	8·77	10·13	11·48	12·79	14·08	15·34	16·58	17·78	18·97	20·12	—	$7\frac{1}{4}$
$7\frac{1}{2}$	4·66	6·16	7·64	9·08	10·51	11·90	13·27	14·61	15·92	17·21	18·47	19·71	20·92	22·10	$7\frac{1}{2}$
$7\frac{3}{4}$	4·82	6·38	7·90	9·40	10·88	12·38	13·75	15·14	16·51	17·85	19·16	20·45	21·71	22·95	$7\frac{3}{4}$
8	4·98	6·59	8·17	9·72	11·25	12·75	14·22	15·67	17·09	18·49	19·85	21·20	22·51	23·80	8
$8\frac{1}{4}$	5·14	6·80	8·43	10·04	11·62	13·18	14·70	16·20	17·68	19·13	20·55	21·94	23·31	24·65	$8\frac{1}{4}$
$8\frac{1}{2}$	5·30	7·01	8·70	10·36	11·99	13·60	15·18	16·73	18·26	19·76	21·24	22·68	24·11	25·50	$8\frac{1}{2}$
$8\frac{3}{4}$	5·46	7·23	8·96	10·68	12·36	14·03	15·66	17·27	18·85	20·40	21·93	23·43	24·90	26·35	$8\frac{3}{4}$
9	5·62	7·44	9·23	11·00	12·74	14·45	16·14	17·80	19·43	21·04	22·62	24·17	25·70	27·20	9
$9\frac{1}{4}$	5·78	7·65	9·50	11·32	13·11	14·88	16·61	18·33	20·01	21·68	23·31	24·92	26·50	28·05	$9\frac{1}{4}$
$9\frac{1}{2}$	5·94	7·86	9·76	11·63	13·48	15·30	17·09	18·86	20·60	22·31	24·00	25·66	27·29	28·90	$9\frac{1}{2}$
$9\frac{3}{4}$	6·10	8·08	10·03	11·95	13·85	15·73	17·57	19·39	21·18	22·95	24·69	26·40	28·09	29·75	$9\frac{3}{4}$
10	6·26	8·29	10·29	12·27	14·22	16·15	18·05	19·92	21·77	23·59	25·38	27·15	28·89	30·60	10
$10\frac{1}{4}$	6·41	8·50	10·56	12·59	14·60	16·58	18·53	20·45	22·35	24·23	26·07	27·89	29·68	31·45	$10\frac{1}{4}$
$10\frac{1}{2}$	6·57	8·71	10·82	12·91	14·97	17·00	19·01	20·98	22·94	24·86	26·76	28·63	30·48	32·30	$10\frac{1}{2}$
$10\frac{3}{4}$	6·73	8·93	11·09	13·23	15·34	17·43	19·48	21·52	23·52	25·50	27·45	29·38	31·28	33·15	$10\frac{3}{4}$
Sum of Flanges (ins.)	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{15}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch														

TABLE OF THE WEIGHT OF ANGLE STEEL IN LBS. PER LINEAL FOOT (concluded).

Sum of Flanges (ins.)	Thickness in Fractions of an Inch: $\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	Sum of Flanges (ins.)
11	6·89	9·14	11·36	13·55	15·71	17·85	19·96	22·05	24·11	26·14	28·14	30·12	32·07	34·00	11
$11\frac{1}{4}$	7·05	9·35	11·62	13·87	16·08	18·28	20·44	22·58	24·69	26·78	28·83	30·87	32·87	34·85	$11\frac{1}{4}$
$11\frac{1}{2}$	7·21	9·56	11·89	14·18	16·46	18·70	20·92	23·11	25·27	27·41	29·52	31·61	33·67	35·70	$11\frac{1}{2}$
$11\frac{3}{4}$	7·37	9·78	12·15	14·50	16·83	19·13	21·40	23·64	25·86	28·06	30·21	32·35	34·46	36·55	$11\frac{3}{4}$
12	7·53	9·99	12·42	14·82	17·20	19·55	21·87	24·17	26·44	28·69	30·91	33·10	35·26	37·40	12
$12\frac{1}{4}$	—	10·20	12·68	15·14	17·57	19·98	22·35	24·70	27·03	29·33	31·60	33·84	36·06	38·25	$12\frac{1}{4}$
$12\frac{1}{2}$	—	10·41	12·95	15·46	17·94	20·40	22·83	25·23	27·61	29·96	32·29	34·58	36·86	39·10	$12\frac{1}{2}$
$12\frac{3}{4}$	—	10·63	13·21	15·78	18·31	20·83	23·31	25·77	28·20	30·60	32·98	35·33	37·65	39·95	$12\frac{3}{4}$
13	—	10·84	13·48	16·10	18·69	21·25	23·79	26·30	28·78	31·24	33·67	36·07	38·45	40·80	13
$13\frac{1}{4}$	—	11·05	13·75	16·42	19·06	21·68	24·26	26·83	29·36	31·88	34·36	36·82	39·25	41·65	$13\frac{1}{4}$
$13\frac{1}{2}$	—	11·26	14·01	16·73	19·43	22·10	24·74	27·36	29·95	32·51	35·05	37·56	40·04	42·50	$13\frac{1}{2}$
$13\frac{3}{4}$	—	11·48	14·28	17·05	19·80	22·53	25·22	27·89	30·53	33·15	35·74	38·30	40·84	43·35	$13\frac{3}{4}$
14	—	—	14·54	17·37	20·17	22·95	25·70	28·42	31·12	33·79	36·43	39·05	41·64	44·20	14
$14\frac{1}{4}$	—	—	14·81	17·69	20·55	23·38	26·18	28·95	31·70	34·43	37·12	39·79	42·43	45·05	$14\frac{1}{4}$
$14\frac{1}{2}$	—	—	15·07	18·01	20·92	23·80	26·66	29·48	32·29	35·06	37·81	40·53	43·23	45·90	$14\frac{1}{2}$
$14\frac{3}{4}$	—	—	15·34	18·33	21·29	24·23	27·13	30·02	32·87	35·70	38·50	41·28	44·03	46·75	$14\frac{3}{4}$
15	—	—	15·61	18·65	21·66	24·65	27·61	30·55	33·46	36·34	39·19	42·02	44·82	47·60	15
Sum of Flanges (ins.)	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in.	Sum of Flanges (ins.)
	Thickness in Fractions of an Inch														

RULE.—*To Calculate the Weight of Angle Bars* :—

w = weight of metal in lbs. per square foot of t thickness.

t = thickness of angle bar in decimals of a foot.

W = weight of angle bar in lbs. per lineal foot.

S = sum of breadth of flanges in decimals of a foot.

$W = (S - t)w$.

Table of the Weight of Round and Square Bar Steel in Lbs. per Lineal Foot.

Width in Ins.	Weight in Lbs. Round	Weight in Lbs. Square	Width in Ins.	Weight in Lbs. Round	Weight in Lbs. Square	Width in Ins.	Weight in Lbs. Round	Weight in Lbs. Square
1/8	·042	·053	3 5/8	35·090	44·678	7 7/8	165·60	210·85
3/16	·094	·120	3/4	37·552	47·813			
1/4	·167	·213	7/8	40·097	51·053	8	170·90	217·60
5/16	·261	·332				1/8	176·29	225·25
3/8	·375	·478	4	42·726	54·400	1/4	181·75	231·41
7/16	·511	·651	1/8	45·438	57·853	3/8	187·30	238·48
1/2	·667	·850	1/4	48·233	61·413	1/2	192·93	245·65
9/16	·845	1·076	3/8	51·112	65·078	5/8	198·65	252·93
5/8	1·043	1·328	1/2	54·075	68·850	3/4	204·45	260·31
11/16	1·262	1·607	5/8	57·121	72·728	7/8	210·33	267·80
3/4	1·502	1·913	3/4	60·250	76·713			
13/16	1·762	2·245	7/8	63·463	80·803	9	216·30	275·40
7/8	2·044	2·603				1/8	222·35	283·10
15/16	2·347	2·988	5	66·759	85·000	1/4	228·48	290·91
			1/8	70·139	89·303	3/8	234·70	298·83
1	2·670	3·400	1/4	73·602	93·713	1/2	241·00	306·85
1/8	3·380	4·303	3/8	77·148	98·229	5/8	248·38	314·98
1/4	4·172	5·313	1/2	80·778	102·85	3/4	253·85	323·21
3/8	5·049	6·428	5/8	84·492	107·58	7/8	260·40	331·55
1/2	6·008	7·650	3/4	88·288	112·41			
5/8	7·051	8·978	7/8	92·169	117·35	10	267·04	340·00
3/4	8·178	10·413				1/8	273·75	348·55
7/8	9·388	11·953	6	96·133	122·40	1/4	280·55	357·21
			1/8	100·18	127·55	3/8	287·44	365·98
2	10·681	13·600	1/4	104·31	132·81	1/2	294·41	374·85
1/8	12·058	15·353	3/8	108·52	138·18	5/8	301·46	383·83
1/4	13·519	17·213	1/2	112·82	143·65	3/4	308·59	392·91
3/8	15·062	19·178	5/8	117·20	149·23	7/8	315·81	402·10
1/2	16·690	21·250	3/4	121·67	154·91			
5/8	18·400	23·428	7/8	126·22	160·70	11	323·11	411·40
3/4	20·195	25·713				1/8	330·50	420·80
7/8	22·072	28·103	7	130·85	166·60	1/4	337·97	430·31
			1/8	135·56	172·60	3/8	345·52	439·93
3	24·033	30·600	1/4	140·36	178·71	1/2	353·15	449·65
1/8	26·078	33·203	3/8	145·24	184·93	5/8	360·87	459·48
1/4	28·206	35·913	1/2	150·21	191·25	3/4	368·68	469·41
3/8	30·417	38·728	5/8	155·26	197·68	7/8	376·56	479·45
1/2	32·712	41·650	3/4	160·39	204·21	12	384·53	489·60
Width in Ins.	Round	Square	Width in Ins.	Round	Square	Width in Ins.	Round	Square
	Weight in Lbs.			Weight in Lbs.			Weight in Lbs.	

TABLE OF THE WEIGHT OF MALLEABLE IRON PIPES IN LBS. PER LINEAL FOOT.

Bore (ins.)	Thickness in Inches									Bore (ins.)
	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	
1	3·27	5·40	7·85	10·63	—	—	—	—	—	1
$\frac{1}{4}$	3·93	6·38	9·16	12·27	15·71	—	—	—	—	$\frac{1}{4}$
$\frac{1}{2}$	4·58	7·36	10·47	13·91	17·67	21·76	—	—	—	$\frac{1}{2}$
$\frac{3}{4}$	5·24	8·34	11·78	15·54	19·63	24·05	28·80	—	—	$\frac{3}{4}$
2	5·89	9·33	13·09	17·18	21·60	26·34	31·41	36·81	—	2
$\frac{1}{4}$	6·55	10·31	14·40	18·82	23·56	28·63	34·03	39·76	45·81	$\frac{1}{4}$
$\frac{1}{2}$	7·20	11·29	15·71	20·45	25·52	30·92	36·65	42·70	49·08	$\frac{1}{2}$
$\frac{3}{4}$	7·85	12·27	16·02	22·09	27·49	33·21	39·27	45·65	52·35	$\frac{3}{4}$
3	8·51	13·25	18·32	23·72	29·45	35·50	41·88	48·59	55·63	3
$\frac{1}{4}$	9·16	14·23	19·63	25·36	31·41	37·79	45·50	51·54	58·90	$\frac{1}{4}$
$\frac{1}{2}$	9·82	15·22	20·94	27·00	33·38	40·08	47·12	54·48	62·17	$\frac{1}{2}$
$\frac{3}{4}$	10·47	16·20	22·25	28·63	35·34	42·37	49·74	57·43	65·45	$\frac{3}{4}$
4	11·13	17·18	23·56	30·27	37·30	44·67	52·35	60·38	68·72	4
$\frac{1}{4}$	11·78	18·16	24·87	31·90	39·27	46·96	54·98	63·32	71·99	$\frac{1}{4}$
$\frac{1}{2}$	12·43	19·14	26·18	33·54	41·23	49·25	57·59	66·26	75·26	$\frac{1}{2}$
$\frac{3}{4}$	13·09	20·12	27·49	35·18	43·20	51·54	60·21	69·21	78·54	$\frac{3}{4}$
5	13·74	21·11	28·80	36·82	45·16	53·83	62·83	72·16	81·8	5
$\frac{1}{4}$	14·40	22·09	30·11	38·45	47·12	56·12	65·45	75·10	85·08	$\frac{1}{4}$
$\frac{1}{2}$	15·05	23·08	31·41	40·08	49·08	58·41	68·06	78·04	88·34	$\frac{1}{2}$
$\frac{3}{4}$	15·71	24·05	32·72	41·72	51·05	60·70	70·68	80·98	91·62	$\frac{3}{4}$
6	16·36	25·03	34·03	43·36	53·01	62·99	73·29	83·93	94·89	6
$\frac{1}{4}$	17·00	26·01	35·34	44·99	54·97	65·27	75·91	86·87	98·16	$\frac{1}{4}$
$\frac{1}{2}$	17·67	27·00	36·65	46·63	56·93	67·57	78·53	89·82	101·44	$\frac{1}{2}$
$\frac{3}{4}$	18·33	27·98	37·96	48·26	58·90	69·86	81·15	92·77	104·71	$\frac{3}{4}$
7	18·98	28·96	39·26	49·90	60·86	72·15	83·77	95·71	107·98	7
$\frac{1}{4}$	19·63	29·93	40·57	51·53	62·82	74·44	86·38	98·65	111·25	$\frac{1}{4}$
$\frac{1}{2}$	20·28	30·92	41·88	53·17	64·79	76·73	89·00	101·60	114·52	$\frac{1}{2}$
$\frac{3}{4}$	20·94	31·90	43·19	54·81	66·75	79·02	91·62	104·24	117·80	$\frac{3}{4}$
8	21·60	32·89	44·51	56·45	68·72	81·32	94·24	107·50	121·07	8
$\frac{1}{4}$	22·25	33·87	45·81	58·08	70·68	83·60	96·86	110·43	124·34	$\frac{1}{4}$
$\frac{1}{2}$	22·91	34·85	47·12	59·72	72·64	85·90	99·47	113·38	127·62	$\frac{1}{2}$
$\frac{3}{4}$	23·56	35·83	48·43	61·35	74·61	88·18	102·29	116·33	130·89	$\frac{3}{4}$
9	24·21	36·81	49·73	62·99	76·56	90·47	104·71	119·27	134·16	9
$\frac{1}{4}$	24·87	37·79	51·05	64·62	78·53	92·77	107·33	122·22	137·43	$\frac{1}{4}$
$\frac{1}{2}$	25·52	38·78	52·35	66·26	80·50	95·06	109·95	125·16	140·70	$\frac{1}{2}$
$\frac{3}{4}$	26·18	39·75	53·66	67·90	82·46	97·35	112·56	128·10	143·97	$\frac{3}{4}$
10	26·83	40·74	54·98	69·54	84·43	99·64	115·18	130·05	147·25	10
$\frac{1}{4}$	27·48	41·72	56·28	71·17	86·38	101·92	117·79	133·99	150·52	$\frac{1}{4}$
$\frac{1}{2}$	28·15	42·71	57·60	72·81	88·35	104·22	120·42	136·95	153·80	$\frac{1}{2}$
$\frac{3}{4}$	28·80	43·69	58·90	74·44	90·31	106·51	123·04	139·89	157·07	$\frac{3}{4}$
11	29·45	44·66	60·20	76·07	92·27	108·80	125·65	142·83	160·33	11
$\frac{1}{2}$	30·75	46·62	62·82	79·35	96·20	113·38	130·88	147·95	166·88	$\frac{1}{2}$
12	32·07	48·60	65·45	82·63	100·13	117·15	136·13	154·61	173·43	12
Bore (ins.)	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	Bore (ins.)
	Thickness in Inches									

Table of the Weight of Cast-iron Pipes in Lbs. per Lineal Foot.

Bore (ins.)	Thickness in Inches									Bore (ins.)
	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	
1	3·06	5·06	7·36	9·97	—	—	—	—	—	1
¼	3·69	5·98	8·59	11·51	14·73	—	—	—	—	¼
½	4·29	6·90	9·82	13·04	16·56	20·4	—	—	—	½
¾	4·91	7·83	11·05	14·57	18·41	22·55	27·00	—	—	¾
2	5·53	8·75	12·27	16·11	20·25	24·7	29·45	34·46	—	2
¼	6·14	9·66	13·50	17·64	22·09	26·84	31·85	37·28	42·95	¼
½	6·74	10·58	14·72	19·17	23·92	28·93	34·36	40·03	46·02	½
¾	7·36	11·50	15·95	20·70	25·71	31·14	36·81	42·80	49·08	¾
3	7·98	12·43	17·18	22·19	27·62	33·29	39·28	45·56	52·16	3
¼	8·59	13·34	18·35	23·78	29·45	35·44	41·72	48·32	55·22	¼
½	9·20	14·21	19·64	25·31	31·30	37·58	44·18	51·08	58·29	½
¾	9·76	15·19	20·86	26·85	33·13	39·73	46·63	53·84	61·36	¾
4	10·44	16·11	22·10	28·38	34·98	41·88	49·09	56·61	64·43	4
¼	11·10	17·08	23·37	29·97	36·87	44·08	51·60	59·42	67·55	¼
½	11·66	17·94	24·54	31·44	38·65	46·17	53·99	62·12	70·56	½
¾	12·27	18·87	25·77	32·98	40·50	48·32	56·45	64·89	73·63	¾
5	12·88	19·78	26·99	34·51	42·33	50·46	58·90	67·64	76·69	5
¼	13·50	20·71	28·23	36·05	44·18	52·62	61·36	70·41	79·77	¼
½	14·11	21·63	29·45	37·58	46·02	54·76	63·81	73·17	82·84	½
¾	14·73	22·55	30·68	39·12	47·86	56·91	66·27	75·94	85·91	¾
6	15·34	23·47	31·91	40·65	49·70	59·06	68·73	78·70	88·75	6
¼	15·95	24·39	33·13	42·18	51·54	61·21	71·18	81·23	92·04	¼
½	16·57	25·31	34·36	43·72	53·39	63·36	73·41	84·22	95·10	½
¾	17·18	26·23	35·59	45·26	55·23	65·28	76·09	86·97	98·18	¾
7	17·79	27·15	36·82	46·79	56·84	67·65	78·53	89·74	101·2	7
¼	18·41	28·08	38·05	48·10	58·91	69·79	81·00	92·50	104·3	¼
½	19·03	29·00	39·05	49·86	60·74	71·95	83·45	95·26	107·4	½
¾	19·64	29·93	40·50	51·38	62·59	74·09	85·90	98·02	110·5	¾
8	20·02	30·83	41·71	52·92	64·42	76·23	88·35	100·8	113·5	8
¼	20·86	31·74	42·95	54·45	66·26	78·38	90·81	103·5	116·6	¼
½	21·69	32·90	44·40	56·21	68·33	80·76	93·49	106·5	119·9	½
¾	22·09	33·59	45·40	57·52	69·95	82·68	95·72	109·1	122·7	¾
9	22·71	34·52	46·64	59·07	71·80	84·84	98·18	111·8	125·8	9
¼	23·31	35·43	47·86	60·59	73·63	86·97	100·6	114·6	128·9	¼
½	23·93	36·36	49·09	62·13	75·47	89·13	103·1	117·4	131·9	½
¾	24·55	37·28	50·32	63·66	77·32	91·28	105·5	120·1	135·0	¾
10	25·16	38·20	51·54	65·20	79·16	93·42	108·0	122·9	138·1	10
¼	25·77	39·11	52·77	66·73	80·99	95·57	110·4	125·6	141·1	¼
½	26·38	40·04	54·00	68·26	82·84	97·71	112·9	128·4	144·2	½
¾	27·00	40·96	55·22	69·80	84·67	99·86	115·4	131·2	147·3	¾
11	27·62	41·88	56·46	71·33	86·52	102·0	117·8	133·9	150·3	11
½	28·84	43·71	58·90	74·39	90·19	106·3	122·7	139·4	156·4	½
12	30·06	45·55	61·35	77·46	93·60	110·6	127·6	145·0	162·6	12
Bore (ins.)	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	Bore (ins.)
	Thickness in Inches									

Table of the Weights of Messrs. James Taylor and Co.'s Steam Winches and Cranes.

Steam winch to lift, in tons .	$1\frac{1}{4}$	2	$2\frac{1}{2}$	3	5	6
Diameter of cylinder in ins. .	5	5	6	7	8	9
Length of stroke in ins. . .	8	10	10	12	12	12
Weight in cwts.	21	34·5	35·5	52	57	88·5
Steam crane to lift, in tons . . .			2	$2\frac{1}{2}$	3	4
Weight with pillar to 'tween decks, in cwts.			73	75	80	84

Table of the Weights of Ships' Galleys.

No. to cook for .	12	25	35	50	60	70	90	100	125
Weight in cwts. .	9	11	16	20	25	26	32	42	44
No. to cook for .	150	220	250	300	400	450	500	600	650
Weight in cwts. .	47	56	66	75	82	102	113	120	135

Table of the Weights of Double and Single Purchase Crabs.

Single Purchase					Double Purchase				
No.	To Lift	Weight with Break			No.	To Lift	Weight with Break		
	Tons	Cwts.	Qrs.	Lbs.		Tons	Cwts.	Qrs.	Lbs.
1	1	2	0	14	10	2	3	1	12
2	$1\frac{1}{2}$	2	1	16	11	3	3	3	14
3	2	3	0	0	12	4	5	1	22
4	3	3	2	12	13	6	6	2	8
5	4	4	3	15	14	8	7	3	0
6	6	5	3	16	15	10	9	3	18
—	—	—	—	—	16	12	11	3	20
—	—	—	—	—	17	16	16	0	0

Table of the Weight of a Cubic Foot and Cubic Inch of Various Metals.

	C. Iron	W. Iron	C. Copper	S. Copper	C. Brass	S. Brass	H. Steel	S. Steel
Cub. ft. in ozs.	7,271	7,680	8,788	8,915	8,396	8,525	7,818	7,833
Cub. ft. in lbs.	454·4	480·0	549·25	557·19	524·75	532·8	488·6	489·6
Cub. in. in ozs.	4·208	4·444	5·086	5·159	4·859	5·333	4·524	4·533
Cub. in. in lbs.	·263	·2777	·3177	·3225	·3037	·3083	·2828	·2833

Weight of Seamless Copper Tubes

Internal Diameter of Tubes (For External Diameter see foot-note, pp. 214–5.)		THICKNESS											
		0000	000	00	0	1	2	3	4	5	6	7	8
		0·454 29/64	0·425 27/64 F	0·380 3/8 F	0·340 11/32	0·300 19/64 F	0·284 9/32 F	0·259 1/4 F	0·238 15/64 F	0·220 7/32 F	0·203 13/64	0·180 3/16 B	0·1 11/6
		11·53	10·79	9·65	8·64	7·62	7·21	6·58	6·04	5·59	5·16	4·57	4·19
In.	Mm.	WEIGHT OF A LINEAL											
1/8	3·2	3·20	2·85	2·34	1·93	1·55	1·42	1·21	1·05	0·92	0·81	0·67	0·58
1/4	6·3	3·89	3·50	2·92	2·45	2·01	1·85	1·61	1·42	1·26	1·12	0·94	0·8
3/8	9·5	4·59	4·14	3·50	2·96	2·47	2·28	2·00	1·78	1·60	1·43	1·22	1·0
1/2	12·7	5·28	4·79	4·08	3·48	2·93	2·71	2·40	2·14	1·93	1·74	1·49	1·3
5/8	15·9	5·97	5·44	4·66	4·00	3·38	3·15	2·79	2·51	2·27	2·05	1·77	1·59
3/4	19·0	6·66	6·09	5·23	4·52	3·84	3·58	3·19	2·87	2·60	2·36	2·04	1·84
7/8	22·2	7·36	6·74	5·81	5·04	4·30	4·01	3·58	3·23	2·94	2·67	2·31	2·09
1	25·4	8·05	7·38	6·39	5·56	4·76	4·45	3·98	3·59	3·27	2·98	2·59	2·34
1 1/8	28·6	8·74	8·03	6·97	6·07	5·21	4·88	4·37	3·96	3·61	3·29	2·86	2·60
1 1/4	31·7	9·43	8·68	7·55	6·59	5·67	5·31	4·77	4·32	3·94	3·60	3·14	2·85
1 3/8	34·9	10·12	9·33	8·13	7·11	6·13	5·74	5·16	4·68	4·28	3·91	3·41	3·10
1 1/2	38·1	10·82	9·98	8·71	7·63	6·59	6·18	5·56	5·05	4·61	4·22	3·69	3·35
1 5/8	41·3	11·51	10·62	9·29	8·15	7·04	6·61	5·95	5·41	4·95	4·53	3·96	3·60
1 3/4	44·4	12·20	11·27	9·87	8·67	7·50	7·04	6·35	5·77	5·29	4·84	4·23	3·85
1 7/8	47·6	12·90	11·92	10·45	9·18	7·96	7·48	6·74	6·14	5·62	5·15	4·51	4·11
2	50·8	13·59	12·57	11·03	9·70	8·42	7·91	7·14	6·50	5·96	5·46	4·78	4·36
2 1/8	54·0	14·28	13·22	11·61	10·22	8·87	8·34	7·53	6·86	6·29	5·76	5·06	4·61
2 1/4	57·1	14·97	13·86	12·19	10·74	9·33	8·78	7·93	7·22	6·63	6·07	5·33	4·86
2 3/8	60·3	15·66	14·51	12·76	11·26	9·78	9·21	8·32	7·59	6·96	6·38	5·60	5·11
2 1/2	63·5	16·35	15·16	13·34	11·78	10·25	9·64	8·72	7·95	7·30	6·69	5·88	5·36
2 5/8	66·7	17·05	15·81	13·92	12·29	10·70	10·07	9·11	8·31	7·63	7·00	6·15	5·[illegible]
2 3/4	69·8	17·74	16·46	14·50	12·81	11·16	10·51	9·51	8·67	7·97	7·31	6·43	5·[illegible]
2 7/8	73·0	18·43	17·10	15·08	13·33	11·62	10·94	9·90	9·04	8·30	7·62	6·70	6·1[illegible]
3	76·2	19·12	17·75	15·66	13·85	12·08	11·37	10·30	9·40	8·64	7·93	6·98	6·[illegible]
3 1/4	82·5	20·51	19·05	16·82	14·89	12·99	12·24	11·09	10·13	9·31	8·55	7·52	6·[illegible]
3 1/2	88·9	21·89	20·34	17·98	15·92	13·91	13·11	11·88	10·85	9·98	9·17	8·07	7·[illegible]
3 3/4	95·2	23·28	21·64	19·14	16·96	14·82	13·97	12·67	11·58	10·65	9·79	8·62	7·[illegible]
4	101·6	24·66	22·94	20·29	18·00	15·74	14·84	13·46	12·30	11·32	10·41	9·17	8·[illegible]
4 1/4	107·9	26·04	24·23	21·45	19·03	16·65	15·70	14·25	13·03	11·99	11·03	9·72	8·[illegible]
4 1/2	114·3	27·43	25·53	22·61	20·07	17·57	16·57	15·04	13·75	12·66	11·65	10·27	9·[illegible]
4 3/4	120·6	28·81	26·82	23·77	21·11	18·48	17·43	15·83	14·48	13·34	12·27	10·82	9·[illegible]
5	127·0	30·20	28·12	24·93	22·14	19·40	18·30	16·62	15·21	14·01	12·89	11·36	10·[illegible]
5 1/4	133·3	31·58	29·42	26·09	23·18	20·31	19·17	17·41	15·93	14·68	13·50	11·91	10·[illegible]
5 1/2	139·7	32·97	30·71	27·25	24·22	21·23	20·03	18·20	16·66	15·35	14·12	12·46	11·[illegible]
5 3/4	146·0	34·35	32·01	28·40	25·25	22·14	20·90	18·99	17·38	16·02	14·74	13·01	11·[illegible]
6	152·4	35·73	33·30	29·56	26·29	23·06	21·76	19·78	18·11	16·69	15·36	13·56	12·[illegible]
6 1/4	158·7	37·12	34·60	30·72	27·33	23·97	22·63	20·57	18·84	17·36	15·93	14·11	12·[illegible]
6 1/2	165·1	38·50	35·90	31·88	28·36	24·89	23·50	21·36	19·56	18·03	16·60	14·66	13·[illegible]

Manufactured by the Broughton Copper Co.

OF COPPER

9	10	11	12	13	14	15	16	17	18	19	20	Wire Gauge	
0·148 9/64 F	0·134 9/64 B	0·120 1/8 B	0·109 7/64	0·095 3/32 F	0·083 5/64 F	0·072 5/64 B	0·065 1/16 F	0·058 1/16 B	0·049 3/64 F	0·042 3/64 B	0·035 1/32 F	Inches	
3·76	3·40	3·05	2·77	2·41	2·11	1·83	1·65	1·47	1·24	1·07	0·89	Millimeters	
FOOT IN POUNDS												Mm.	In.
0·49	0·42	0·36	0·31	0·25	0·21	0·17	0·15	0·13	0·10	0·09	0·07	3·2	1/8
0·72	0·63	0·54	0·48	0·40	0·34	0·28	0·25	0·22	0·18	0·15	0·12	6·3	1/4
0·94	0·83	0·72	0·64	0·54	0·46	0·39	0·35	0·31	0·25	0·21	0·17	9·5	3/8
1·17	1·04	0·91	0·81	0·69	0·59	0·50	0·45	0·39	0·33	0·28	0·23	12·7	1/2
1·39	1·24	1·09	0·98	0·83	0·72	0·61	0·55	0·48	0·40	0·34	0·28	15·9	5/8
1·62	1·44	1·27	1·14	0·98	0·84	0·72	0·65	0·57	0·48	0·41	0·33	19·0	3/4
1·84	1·65	1·46	1·31	1·12	0·97	0·83	0·75	0·66	0·55	0·47	0·39	22·2	7/8
2·07	1·85	1·64	1·47	1·27	1·10	0·94	0·84	0·75	0·63	0·53	0·44	25·4	1
2·30	2·06	1·82	1·64	1·41	1·22	1·05	0·94	0·84	0·70	0·60	0·49	28·6	1 1/8
2·52	2·26	2·00	1·81	1·56	1·35	1·16	1·04	0·92	0·77	0·66	0·55	31·7	1 1/4
2·75	2·46	2·19	1·97	1·70	1·48	1·27	1·14	1·01	0·85	0·73	0·60	34·9	1 3/8
2·97	2·67	2·37	2·14	1·85	1·60	1·38	1·24	1·10	0·92	0·79	0·65	38·1	1 1/2
3·20	2·87	2·55	2·31	1·99	1·73	1·49	1·34	1·19	1·00	0·85	0·71	41·3	1 5/8
3·42	3·08	2·74	2·47	2·14	1·86	1·60	1·44	1·28	1·07	0·92	0·76	44·4	1 3/4
3·65	3·28	2·92	2·64	2·28	1·98	1·71	1·54	1·37	1·15	0·98	0·81	47·6	1 7/8
3·87	3·49	3·10	2·80	2·43	2·11	1·82	1·64	1·45	1·22	1·05	0·87	50·8	2
4·10	3·69	3·28	2·97	2·57	2·24	1·93	1·74	1·54	1·30	1·11	0·92	54·0	2 1/8
4·33	3·89	3·47	3·14	2·72	2·36	2·04	1·84	1·63	1·37	1·18	0·97	57·1	2 1/4
4·55	4·10	3·65	3·30	2·86	2·49	2·15	1·93	1·72	1·45	1·24	1·03	60·3	2 3/8
4·78	4·30	3·83	3·47	3·01	2·62	2·26	2·03	1·81	1·52	1·30	1·08	63·5	2 1/2
5·00	4·51	4·02	3·64	3·15	2·74	2·36	2·13	1·90	1·60	1·37	1·13	66·7	2 5/8
5·23	4·71	4·20	3·80	3·30	2·87	2·47	2·23	1·98	1·67	1·43	1·19	69·8	2 3/4
5·45	4·91	4·38	3·97	3·44	3·00	2·58	2·33	2·07	1·74	1·50	1·24	73·0	2 7/8
5·68	5·12	4·57	4·13	3·59	3·12	2·69	2·43	2·16	1·82	1·56	1·29	76·2	3
6·13	5·53	4·93	4·47	3·88	3·38	2·91	2·63	2·34	1·97	1·69	1·40	82·5	3 1/4
6·58	5·94	5·30	4·80	4·17	3·63	3·13	2·83	2·51	2·12	1·82	1·51	88·9	3 1/2
7·03	6·34	5·66	5·13	4·46	3·88	3·35	3·03	2·69	2·27	1·95	1·61	95·2	3 3/4
7·48	6·75	6·03	5·46	4·75	4·14	3·57	3·22	2·87	2·42	2·07	1·72	101·6	4
7·93	7·16	6·40	5·80	5·04	4·39	3·79	3·42	3·05	2·57	2·20	1·83	107·9	4 1/4
8·38	7·57	6·76	6·13	5·33	4·64	4·01	3·62	3·22	2·71	2·33	1·93	114·3	4 1/2
8·83	7·98	7·13	6·46	5·62	4·90	4·23	3·82	3·40	2·86	2·46	2·04	120·6	4 3/4
9·28	8·39	7·49	6·79	5·91	5·15	4·45	4·02	3·57	3·01	2·59	2·15	127·0	5
9·74	8·79	7·86	7·13	6·20	5·40	4·67	4·22	3·75	3·16	2·71		133·3	5 1/4
10·19	9·20	8·22	7·46	6·49	5·66	4·89	4·41	3·93	3·31	2·84		139·7	5 1/2
10·64	9·61	8·59	7·79	6·78	5·91	5·11	4·61	4·10	3·46	2·97		146·0	5 3/4
11·09	10·02	8·96	8·12	7·07	6·16	5·33	4·81	4·28	3·61	3·10		152·4	6
11·54	10·43	9·32	8·46	7·36	6·42	5·54	5·01	4·46	3·76			158·7	6 1/4
11·99	10·84	9·69	8·79	7·65	6·67	5·76	5·21	4·63	3·91			165·1	6 1/2

Weight of Seamless

Internal Diameter of Tubes (For External Diameter see foot-note.)		THICKNESS 0000	000	00	0	1	2	3	4	5	6	7	8
		0·454 29/64	0·425 27/64 F	0·380 3/8 F	0·340 11/32	0·300 19/64 F	0·284 9/32 F	0·259 1/4 F	0·238 15/64 F	0·220 7/32 F	0·203 13/64	0·180 3/16 B	0·165 11/64 B
		11·53	10·79	9·65	8·64	7·62	7·21	6·58	6·04	5·59	5·16	4·57	4·19
In.	Mm.	WEIGHT OF A LINEAL											
6¾	171·4	39·89	37·19	33·04	29·40	25·80	24·36	22·15	20·29	18·70	17·22	15·20	13·92
7	177·8	41·27	38·49	34·20	30·44	26·72	25·23	22·94	21·01	19·37	17·84	15·75	14·42
7¼	184·1	42·66	39·78	35·36	31·47	27·63	26·09	23·73	21·74	20·04	18·46	16·30	14·93
7½	190·5	44·04	41·08	36·51	32·51	28·55	26·96	24·52	22·46	20·72	19·08	16·85	15·43
7¾	196·8	45·42	42·38	37·67	33·55	29·46	27·83	25·31	23·19	21·39	19·69	17·40	15·93
8	203·2	46·81	43·67	38·83	34·58	30·38	28·69	26·10	23·92	22·06	20·31	17·95	16·44
8¼	209·5	48·19	44·97	39·99	35·62	31·29	29·56	26·89	24·64	22·73	20·93	18·49	16·94
8½	215·9	49·58	46·26	41·15	36·66	32·21	30·42	27·68	25·37	23·40	21·55	19·04	17·44
8¾	222·3	50·96	47·56	42·31	37·69	33·12	31·29	28·47	26·09	24·07	22·17	19·59	17·95
9	228·6	52·35	48·86	43·46	38·73	34·04	32·15	29·26	26·82	24·74	22·79	20·14	18·45
9¼	235·0	53·73	50·15	44·62	39·77	34·95	33·02	30·05	27·55	25·41	23·41	20·69	18·95
9½	241·3	55·11	51·45	45·78	40·80	35·87	33·89	30·84	28·27	26·08	24·03	21·24	19·46
9¾	247·7	56·50	52·74	46·94	41·84	36·78	34·75	31·63	29·00	26·75	24·65	21·79	19·96
10	254·0	57·88	54·04	48·10	42·88	37·70	35·62	32·42	29·72	27·42	25·27	22·33	20·46
10¼	260·4	59·27	55·34	49·26	43·90	38·61	36·48	33·21	30·45	28·09	25·89	22·88	20·97
10½	266·7	60·65	56·63	50·42	44·94	39·53	37·35	34·00	31·17	28·77	26·51	23·43	21·47
10¾	273·1	62·04	57·93	51·57	45·98	40·44	38·22	34·79	31·90	29·44	27·12	23·98	21·97
11	279·4	63·42	59·22	52·73	47·01	41·36	39·08	35·58	32·63	30·11	27·74	24·53	22·48
11¼	285·8	64·80	60·52	53·89	48·05	42·27	39·95	36·37	33·35	30·78	28·36	25·08	22·98
11½	292·1	66·19	61·82	55·05	49·09	43·19	40·81	37·16	34·08	31·45	28·98	25·62	23·48
11¾	298·5	67·57	63·11	56·21	50·12	44·10	41·68	37·95	34·80	32·12	29·60	26·17	23·99
12	304·8	68·96	64·41	57·37	51·16	45·02	42·55	38·74	35·53	32·79	30·22	26·72	24·49
12¼	311·2	70·34	65·70	58·53	52·20	45·93	43·41	39·53	36·25	33·46	30·83	27·27	24·99
12½	317·5	71·73	67·00	59·68	53·23	46·85	44·28	40·32	36·98	34·13	31·46	27·82	25·50
12¾	323·9	73·11	68·30	60·84	54·27	47·76	45·14	41·11	37·71	34·80	32·06	28·37	26·00
13	330·2	74·49	69·59	62·00	55·31	48·68	46·01	41·90	38·43	35·47	32·70	28·92	26·50
13¼	336·6	75·88	70·89	63·16	56·34	49·59	46·88	42·69	39·16	36·14	33·32	29·46	27·01
13½	342·9	77·26	72·18	64·32	57·38	50·51	47·74	43·48	39·88	36·82	33·94	30·01	27·51
13¾	349·3	78·65	73·48	65·48	58·42	51·42	48·61	44·27	40·61	37·49	34·56	30·56	28·01
14	355·6	80·03	74·78	66·63	59·45	52·34	49·47	45·06	41·34	38·16	35·17	31·11	28·52
		5·03	4·42	3·52	2·82	2·21	1·97	1·66	1·38	1·18	1·01	0·78	0·67

If the external diameter is given, subtract figure at bottom of column; for example, the weight per lineal foot of a copper tube 2" external diameter, 12 w.g., is 2·80−0·29=2·51 lbs.

To ascertain the weight of a seamless tube of other metal, multiply the weight of a similar copper tube by 0·95 for brass, by 0·86 for wrought iron, by 0·80 for cast iron, or by 1·27 for lead.

Copper Tubes, &c.—*continued.*

OF COPPER

9	10	11	12	13	14	15	16	17	18	19	20	Wire Gauge	
0·148 9/64 F	0·134 9/64 B	0·120 1/8 B	0·109 7/64	0·095 3/32 F	0·083 5/64 F	0·072 5/64 B	0·065 1/16 F	0·058 1/16 B	0·049 3/64 F	0·042 3/64 B	0·035 1/32 F	Inches	
3·76	3·40	3·05	2·77	2·41	2·11	1·83	1·65	1·47	1·24	1·07	0·89	Millimetres	
FOOT IN POUNDS												Mm.	In.
12·44	11·25	10·05	9·12	7·94	6·92	5·98	5·41	4·81	4·06			171·4	6¾
12·89	11·65	10·42	9·45	8·28	7·18	6·20	5·60	4·99	4·21			177·8	7
13·34	12·06	10·79	9·79	8·52	7·43	6·42	5·80	5·17				184·1	7¼
13·79	12·47	11·15	10·12	8·81	7·68	6·64	6·00	5·34				190·5	7½
14·25	12·88	11·52	10·45	9·10	7·94	6·86	6·20	5·52				196·8	7¾
14·70	13·29	11·88	10·78	9·39	8·19	7·08	6·40	5·70				203·2	8
15·15	13·70	12·25	11·12	9·68	8·44	7·30	6·60					209·5	8¼
15·60	14·10	12·61	11·45	9·97	8·69	7·52	6·79					215·9	8½
16·05	14·51	12·98	11·78	10·26	8·95	7·74	6·99					222·3	8¾
16·50	14·92	13·35	12·11	10·55	9·20	7·96	7·19					228·6	9
16·95	15·33	13·71	12·45	10·84	9·46	8·18						235·0	9¼
17·40	15·74	14·08	12·78	11·13	9·71	8·39						241·3	9½
17·85	16·15	14·44	13·11	11·42	9·96	8·61						247·7	9¾
18·30	16·55	14·81	13·44	11·71	10·22	8·83						254·0	10
18·75	16·96	15·18	13·78	12·00	10·47							260·4	10¼
19·21	17·37	15·54	14·11	12·29	10·72							266·7	10½
19·66	17·78	15·91	14·44	12·58	10·97							273·1	10¾
20·11	18·19	16·27	14·77	12·87	11·23							279·4	11
20·56	18·10	16·65	15·11	13·16								285·8	11¼
21·01	19·00	17·01	15·44	13·45								292·1	11½
21·46	19·41	17·37	15·77	13·74								298·5	11¾
21·91	19·82	17·74	16·10	14·03								304·8	12
22·36	20·23	18·10	16·44									311·2	12¼
22·81	20·64	18·47	16·77									317·5	12½
23·26	21·05	18·83	17·10									323·9	12¾
23·72	21·46	19·20	17·43									330·2	13
24·17	21·86	19·57										336·6	13¼
24·62	22·27	19·93										342·9	13½
25·07	22·68	19·30										349·3	13¾
25·52	23·09	20·66										355·6	14
0·53	0·48	0·35	0·29	0·22	0·17	0·13	0·11	0·08	0·06	0·05	0·03		

Decimal Equivalents of Inches and Feet

⅛	=	·01041
¼	=	·02083
⅜	=	·03125
½	=	·04166
⅝	=	·05208
¾	=	·06250
⅞	=	·07291
1	=	·08333
2	=	·16666
3	=	·25000
4	=	·33333
5	=	·41666
6	=	·50000
7	=	·58333
8	=	·66666
9	=	·75000
10	=	·83333
11	=	·91666
12	=	1·00000

Brazed copper tubes weigh more per lineal foot than seamless; but an exact constant multiple cannot be given, as the proportion of difference in weight varies with the thickness, the diameter, and the class of joint of the brazed tube. Mandrildrawn brazed tubes weigh the same as seamless tubes.

The above weights are theoretically correct; but in practice a slight deviation from the theoretical weight must be expected. F, full. B, bare.

TABLE OF THE WEIGHT OF LEAD PIPE IN LBS. PER LINEAL FOOT, AND LENGTHS IN WHICH IT IS USUALLY MANUFACTURED.

Lgth. (ft.)	Bore (ins.)	Weight per Foot in Lbs.							Lgth. (ft.)	Bore (ins.)	Wght. per Ft. in Lbs.			
15 *	⅜	·933	1·07	1·2	1·47	1·73	1·87	2·33	12	3	9·0	—	—	—
	½	1 2	1·47	1·67	1·80	—	—	—	10	2¼	13·0	—	—	—
	¾	1·47	1·60	1·73	1·87	2·13	2·4	3·00		2½	9·6	10·5	12·0	—
	1	1·87	2·4	2·8	3·00	3·60	3 93	4·20		3	11·6	12·0	13·4	15·0
12 †	1¼	3·00	3·17	3·50	4·33	5·08	5·25	—		3½	13·5	15·0	16·6	18·4
	1½	3·50	4·00	4·67	5·08	6·00	7·00	—		4	13·5	16·0	18·4	20·0
	1¾	5·83	7·00	7 33	8·00	—	—	—		4½	20·0	21·6	23·4	—
	2	7·00	8·00	9·33	—	—	—	—		5	23·4	25·4	28·0	—
	2½	10·5	—	—	—	—	—	—		6	33·0	—	—	—

* Also in 60-feet coils. † Also in 36-feet coils.

TABLE OF THE WEIGHT OF CAST-IRON BALLS.

Diam. (ins.)	Wght. (lbs.)	Diam. (ins.)	Wght. (lbs.)	Diam. (ins.)	Weight (lbs.)	Diam (ins.)	Weight (lbs.)	Diam. (ins.)	Weight (lbs.)
—	—	—	—	4½	12·55	6⅜	35·68	8½	84·57
1	·14	2¾	2·86	4⅝	13·62	6½	37·81	8¾	92·25
1⅛	·20	2⅞	3·27	4¾	14·76	6⅝	40·04	9	100·39
1¼	·27	3	3·72	4⅞	15·95	6¾	42·35	9¼	108·99
1⅜	·36	3⅛	4·20	5	17·21	6⅞	44·75	9½	118·06
1½	·47	3¼	4·73	5⅛	18·54	7	47·23	9¾	127·63
1⅝	·59	3⅜	5 29	5¼	19·93	7⅛	49·80	10	137·70
1¾	·74	3½	5·90	5⅜	21·38	7¼	52·47	10¼	148 29
1⅞	·91	3⅝	6·56	5½	22·91	7⅜	55·23	10½	159·40
2	1·10	3¾	7·26	5⅝	24·51	7½	58·09	10¾	171·06
2⅛	1·32	3⅞	8·01	5¾	26·18	7⅝	60·04	11	183·28
2¼	1·57	4	8·81	5⅞	27·92	7¾	64·09	11¼	196·06
2⅜	1 84	4⅛	9·67	6	29·74	7⅞	67·24	11½	209·42
2½	2·15	4¼	10·57	6⅛	31·64	8	70·50	11¾	223·38
2⅝	2·49	4⅜	11·53	6¼	33·62	8¼	77·92	12	237·94

SHRINKAGE OF CASTINGS.

The usual allowance for each foot in length is as follows:—

In large cylinders .	$=\frac{3}{32}$ inch.	In zinc . .	$=\frac{5}{16}$ inch.
In small „ .	$=\frac{1}{16}$ „	In lead . .	$=\frac{5}{16}$ „
In beams and girders	$=\frac{1}{10}$ „	In tin . .	$=\frac{1}{4}$ „
In thick brass .	$=\frac{5}{32}$ „	In copper . .	$=\frac{3}{16}$ „
In thin „ .	$=\frac{4}{32}$ „	In bismuth .	$=\frac{5}{32}$ „

In cast-iron pipes $=\frac{1}{8}$ inch.

TABLE OF THE WEIGHT OF COPPER PIPE IN LBS. PER LINEAL FOOT.

Thickness (ins.)	Bore of Pipe in Inches								Thickness (ins.)
	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	
$\frac{1}{32}$	·11	·13	·15	·20	·25	·30	·34	·39	$\frac{1}{32}$
$\frac{1}{16}$	·24	·28	·33	·43	·52	·61	·71	·80	$\frac{1}{16}$
$\frac{3}{32}$	·39	·46	·53	·67	·82	·96	1·10	1·24	$\frac{3}{32}$
$\frac{1}{8}$	·57	·66	·76	·95	1·14	1·32	1·51	1·70	$\frac{1}{8}$
$\frac{5}{32}$	·77	·89	1·01	1·24	1·48	1·71	1·95	2·19	$\frac{5}{32}$
$\frac{3}{16}$	·99	1·14	1·28	1·56	1·84	2·13	2·41	2·70	$\frac{3}{16}$
$\frac{7}{32}$	1·24	1·41	1·57	1·90	2·23	2·57	2·90	3·23	$\frac{7}{32}$
$\frac{1}{4}$	1·51	1·70	1·89	2·27	2·65	3·03	3·41	3·78	$\frac{1}{4}$

Thickness (ins.)	Bore of Pipe in Inches								Thickness (ins.)
	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	
$\frac{1}{16}$	·90	·99	1·09	1·18	1·28	1·37	1·47	1·56	$\frac{1}{16}$
$\frac{1}{8}$	1·89	2·08	2·27	2·46	2·65	2·84	3·03	3·22	$\frac{1}{8}$
$\frac{3}{16}$	2·98	3·26	3·55	3·83	4·12	4·40	4·68	4·97	$\frac{3}{16}$
$\frac{1}{4}$	4·16	4·54	4·91	5·30	5·67	6·05	6·43	6·81	$\frac{1}{4}$

Thickness (ins.)	Bore of Pipe in Inches								Thickness (ins.)
	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{7}{8}$	3	
$\frac{1}{16}$	1·66	1·75	1·84	1·94	2·04	2·13	2·22	2·32	$\frac{1}{16}$
$\frac{1}{8}$	3·41	3·59	3·78	3·98	4·16	4·35	4·54	4·73	$\frac{1}{8}$
$\frac{3}{16}$	5·25	5·53	5·82	6·10	6·39	6·67	6·95	7·24	$\frac{3}{16}$
$\frac{1}{4}$	7·19	7·57	7·94	8·33	8·70	9·08	9·46	9·84	$\frac{1}{4}$

Thickness (ins.)	Bore of Pipe in Inches								Thickness (ins.)
	$3\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{1}{2}$	$3\frac{5}{8}$	$3\frac{3}{4}$	$3\frac{7}{8}$	4	
$\frac{1}{16}$	2·41	2·51	2·60	2·70	2·79	2·89	2·98	3·08	$\frac{1}{16}$
$\frac{1}{8}$	4·92	5·11	5·30	5·49	5·68	5·87	6·05	6·25	$\frac{1}{8}$
$\frac{3}{16}$	7·52	7·81	8·09	8·37	8·66	8·94	9·22	9·51	$\frac{3}{16}$
$\frac{1}{4}$	10·22	10·60	10·97	11·35	11·73	12·11	12·49	12·51	$\frac{1}{4}$

Table of the Weight of Hoop Iron in Lbs. per Lineal Foot.

Breadth (ins.)	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$
Thickness (B.W.G.)	23	22	21	20	19	18	17
Weight (lbs.)	·0313	·0466	·0666	·0875	·1225	·1633	·2175
Breadth (ins.)	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$
Thickness (B.W.G.)	16	15	15	14	13	13	12
Weight (lbs.)	·2708	·3300	·3600	·4842	·6333	·7125	·9083

Table of the Weight of Iron, Steel, Brass, and Copper Wire in Lbs. per Lineal Foot.

B.W.G.	Lbs. per Lineal Foot				B.W.G.	Lbs. per Lineal Foot			
	Iron	Steel	Brass	Copper		Iron	Steel	Brass	Copper
0	·3058	·3092	·3343	·3517	11	·0413	·0418	·0452	·0475
1	·2575	·2604	·2815	·2962	12	·0314	·0318	·0343	·0361
2	·2134	·2157	·2332	·2454	13	·0234	·0236	·0255	·0269
3	·1802	·1822	·1970	·2072	14	·0169	·0171	·0185	·0195
4	·1511	·1528	·1652	·1738	15	·0137	·0139	·0150	·0158
5	·1246	·1259	·1362	·1433	16	·0105	·0106	·0115	·0121
6	·1145	·1157	·1251	·1316	17	·0080	·0081	·0087	·0092
7	·0925	·0935	·1011	·1064	18	·0061	·0062	·0067	·0070
8	·0729	·0737	·0797	·0838	19	·0047	·0047	·0051	·0054
9	·0660	·0668	·0722	·0759	20	·0032	·0033	·0034	·0037
10	·0496	·0502	·0543	·0571	21	·0017	·0018	·0019	·0022

Table of the Weight of Nuts and Bolt-heads in Lbs. per Pair.

Diameter of bolt (ins.)	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Hexagon head and nut	·050	·100	·200	·365	·500	·770	1·25
Square head and nut	·062	·121	·240	·400	·560	·880	1·31
Diameter of bolt (ins.)	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{2}$
Hexagon head and nut	1·75	2·13	3·00	3·75	5·75	8·75	17·00
Square head and nut	2·10	2·56	3·60	4·42	7·00	10·5	21·00

WEIGHTS OF MOUNTINGS FOR ELSWICK GUNS.

—	1 Pdr. Bulwark			1 Pdr. Deck			$1\frac{1}{2}$ Pdr. Pedestal			3 Pdr. Bulwark			3 Pdr. Deck Jacket Recoil			3 Pdr. Deck			3 Pdr. Housing		
	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.
Cradle		—			—			3	0	2	1	2	2	2	21	2	1	2	2	3	1
Mounting		1	21		1	21		2	10	1	3	20	1	1	5	1	3	20	7	1	22
Outer shield		3	14		3	14	1	1	25		3	17	8	1	14		3	17	1	0	8
Inner shield		—			—			—			—			—			—			—	
Pedestal		3	14	1	0	13	1	1	6		—		3	1	16	2	3	5		—	
Pivot plate		2	2		2	2		2	2		2	0		2	19		2	0		2	19
Total	2	2	23	2	3	22	4	2	15	5	2	11	16	1	19	8	1	16	11	3	22
Elevation		25°			25°			25°			25°			25°			25°			15°	
Depression		35°			30°			15°			15°			15°			15°			15°	
Thickness of shield		$\frac{1}{4}''$			$\frac{1}{4}''$			$\frac{5}{16}''$			$\frac{3}{16}''$ flat			1″			$\frac{3}{16}''$ flat			$\frac{3}{4}''$	

—	6 Pdr. Bulwark			6 Pdr. Deck			6 Pdr. Housing			10 Pdr. Boat			12 Pdr. Boat			12 Pdr. Pedestal 'Light'			12 Pdr. Pedestal 'Heavy'		
	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.	Cwt.	Qrs.	Lbs.
Cradle	2	3	7	2	3	7	2	3	7	3	3	23	3	3	23	4	2	14	4	2	14
Mounting	1	3	24	1	3	24	7	1	22	1	2	1	1	2	1	4	2	15	7	1	10
Outer shield		3	22		3	22	1	0	8	1	0	13	1	0	13	2	2	26	35	1	10
Inner shield		—			—			—			1	27		1	27		—			—	
Pedestal		—		2	3	5		—			—			—		4	0	10	9	2	0
Pivot plate		2	0		2	0		2	0		1	27		1	27		—			—	
Total	6	0	25	9	0	2	11	3	9	7	2	7	7	2	7	16	0	9	56	2	24
Elevation		25°			25°			15°			20°			20°			20°			20°	
Depression		15°			15°			15°			10°			10°			10°			10°	
Thickness of shield		$\frac{3}{16}''$ flat			$\frac{3}{16}''$ flat			$\frac{1}{4}''$			$\frac{3}{16}''$ outer, $1\frac{1}{4}''$ inner			$\frac{3}{16}''$ outer, $1\frac{1}{4}''$ inner			·22″ flat			3″	

NOTE.—3 pdr. and 6 pdr. mountings can be fitted with heavy circular shields 1″ thick, which weigh 8 cwt. each.

WEIGHTS OF MOUNTINGS FOR ELSWICK GUNS—*continued.*

—	20 Pdr. Pedestal				4 Inch Pedestal				4·7 Inch Pedestal 40-calibre gun				4·7 Inch Pedestal 45-calibre gun				6 Inch Pedestal Upper Deck				6 Inch Pedestal Between Deck			
	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.
Cradle . . .		8	0	11		11	1	27		12	3	0		13	1	24	1	10	0	10	1	9	2	16
Mounting . .		7	0	9		13	2	11		13	3	24		13	3	24	1	13	2	12	1	10	2	17
Outer shield . .	2	4	0	0	2	8	1	22	3	17	1	3	3	17	1	13	4	9	2	24	1	6	0	12
Inner shield . .		—				—				2	2	25		2	2	15		—				—		
Pedestal . . .		6	1	15		12	0	4		13	0	0		13	0	0		19	1	25		19	1	25
Pivot plate . .		—				—				—				—				—				—		
Total . .	3	5	2	7	4	5	2	8	5	19	2	24	6	0	1	20	8	12	3	15	5	5	3	14
Elevation . .	20°				20°				20°				20°				16°				15°			
Depression . .	7°				7°				7°				7°				7°				7°			
Thickness of shield	1¼″ outer, 3′ inner				4½″ tapered				4½″ outer, 3″ inner				4½″ outer, 3″ inner				4½″, 1¼″ wings				3″			

—	6 Inch Pedestal 45-calibre gun				8 Inch Centre Pivot 40-calibre gun				8 Inch Centre Pivot 45-calibre gun			
	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.	Tons	Cwt.	Qrs.	Lbs.
Cradle . . .	1	18	1	17	3	2	0	0	3	19	1	11
Mounting . .	2	3	1	2	4	0	0	0	4	0	0	0
Outer shield . .	5	13	1	26	6	16	0	0	7	15	2	0
Inner shield . .		18	0	18		—				—		
Pedestal . .		—				—				—		
Pivot plate . .		14	1	18	1	7	0	0	1	7	0	20
Total . .	11	7	2	15	15	5	0	0	17	2	0	3
Elevation . .	19°				15°				15°			
Depression . .	7°				5°				5°			
Thickness of shield	4½′, 1¼″ wings				4″				4 ′			

10 Inch High Angle Mounting 40-calibre gun	Tons	Cwt.	Qrs.	Lbs.
Turntable, carriage, rollers, shell-carrier, and gear	22	13	0	24
Roller path	3	2	0	0
Gun-house	30	0	0	0
	55	15	0	24
Gun	30	0	0	0
Total	85	15	0	24
Elevation	85°			
Depression	5°			

Ballistics and Weights of Elswick Naval Guns, Elswick Works, Newcastle-on-Tyne.

Diameter of bore . . . . ins.	1·46	1·46	1·85	1·85*	2·244	2·244	3	3	3·5	4	4		4·7	4·7
" " . . . . mm.	37	37	47	47	57	57	76	76	89	102	102		120	120
Length in " . . . . calibres	25	45	40	46	40	50	40	50	40	45	50		45	50
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.		Cwt.	Cwt.
Weight of gun	79	268	506	550	800	10	12	18	24	38	40		55	57
" projectiles . . . . lbs.	1·1	1·5	3·3	3·3	6	6	12·5	12·5	20	25	25	31	45	45
	Oz.	Oz.	Oz.	Oz.	Oz.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
" cordite charge . . .	1·125	4·5	7·94	8·0	9·2	1·3	1·94	3·0	4·0	7·75	7·75	7·75	10	10
Muzzle velocity . . . . F.S.	1,540	2,300	2,132	2,300	1,968	2,592	2,335	2,800	2,430	2,935	3,000	2,800	2,670	2,750
" energy . . . . F.T.	18	55	104	121	161	280	473	680	819	1,493	1,560	1,685	2,224	2,360
Penetration, wrot. iron at muzzle ins.	1·9	4·3	5·2	5·7	5·6	8·6	8·8	11·6	11·0	14·5	15·0	16·0	16·2	17·0
Rounds per minute	—	25	30	30	25	25	20	20	17	15	15	15	10	10

													Old Pattern
Diameter of bore . . . . ins.	5·87	6	6	7·5	8	8	8·24	9·2	10	10	12	12	13·5
" " . . . . mm.	149	152	152	190	203	203	210	234	254	254	305	305	343
Length in " . . . . calibres	46	40	50	45	45	48·3	44	45	40	45	40	40	30
Weight of gun . . . . tons	7	6·6	9·0	13	18·5	19·7	18·1	28	30	38	49	50	68
" projectile . . . lbs.	99·25	100	100	200	210	210	308·6	380	450	450	850	850	1,350
" cordite charge . . lbs.	21·5	18·5	36·0	65	47	67	47	105	81·5	125	141	230	223
Muzzle velocity . . . . F.S.	2,625	2,500	3,000	2,900	2,650	3,000	2,300	2,800	2,400	2,756	2,400	2,650	2,016
" energy . . . . F.T.	4,742	4,334	6,240	11,663	10,226	13,105	11,320	20,658	17,973	23,702	33,949	41,390	38,046
Penetration, wrot. iron at muzzle ins.	21·5	19·5	25·7	31·0	26·0	31·1	27·0	36·9	29·9	37·0	38·4	44·7	36·2
Rounds per minute	8	8	8	5	4	4	3	2	2	2	8 rounds have been fired in 2 min. 10 secs. from a pair of guns		4 rounds in 6 min.

* Also arranged for landing carriage.

WEIGHT OF SEAMLESS COPPER TUBES

Internal Diameter of Tubes (For External Diameter see footnote, pp. 214-5.)		THICKNESS											
		0000	000	00	0	1	2	3	4	5	6	7	8
		0·454 29/64	0·425 27/64 F	0·380 3/8 F	0·340 11/32	0·300 19/64 F	0·284 9/32 F	0·259 1/4 F	0·238 15/64 F	0·220 7/32 F	0·203 13/64	0·180 3/16 B	0·165 11/64 B
		11·53	10·79	9·65	8·64	7·62	7·21	6·58	6·04	5·59	5·16	4·57	4·19
In.	Mm.	WEIGHT OF A LINEAL											
1/8	3·2	3·20	2·85	2·34	1·98	1·55	1·42	1·21	1·05	0·92	0·81	0·67	0·58
1/4	6·3	3·89	3·50	2·92	2·45	2·01	1·85	1·61	1·42	1·26	1·12	0·94	0·83
3/8	9·5	4·59	4·14	3·50	2·96	2·47	2·28	2·00	1·78	1·60	1·43	1·22	1·09
1/2	12·7	5·28	4·79	4·08	3·48	2·93	2·71	2·40	2·14	1·93	1·74	1·49	1·34
5/8	15·9	5·97	5·44	4·66	4·00	3·38	3·15	2·79	2·51	2·27	2·05	1·77	1·59
3/4	19·0	6·66	6·09	5·23	4·52	3·84	3·58	3·19	2·87	2·60	2·36	2·04	1·84
7/8	22·2	7·36	6·74	5·81	5·04	4·30	4·01	3·58	3·23	2·94	2·67	2·31	2·09
1	25·4	8·05	7·38	6·39	5·56	4·76	4·45	3·98	3·59	3·27	2·98	2·59	2·34
1 1/8	28·6	8·74	8·03	6·97	6·07	5·21	4·88	4·37	3·96	3·61	3·29	2·86	2·60
1 1/4	31·7	9·43	8·68	7·55	6·59	5·67	5·31	4·77	4·32	3·94	3·60	3·14	2·85
1 3/8	34·9	10·12	9·33	8·13	7·11	6·13	5·74	5·16	4·68	4·28	3·91	3·41	3·10
1 1/2	38·1	10·82	9·98	8·71	7·63	6·59	6·18	5·56	5·05	4·61	4·22	3·69	3·35
1 5/8	41·3	11·51	10·62	9·29	8·15	7·04	6·61	5·95	5·41	4·95	4·53	3·96	3·60
1 3/4	44·4	12·20	11·27	9·87	8·67	7·50	7·04	6·35	5·77	5·29	4·84	4·23	3·85
1 7/8	47·6	12·90	11·92	10·45	9·18	7·96	7·48	6·74	6·14	5·62	5·15	4·51	4·11
2	50·8	13·59	12·57	11·03	9·70	8·42	7·91	7·14	6·50	5·96	5·46	4·78	4·36
2 1/8	54·0	14·28	13·22	11·61	10·22	8·87	8·34	7·53	6·86	6·29	5·76	5·06	4·61
2 1/4	57·1	14·97	13·86	12·19	10·74	9·33	8·78	7·93	7·22	6·63	6·07	5·33	4·86
2 3/8	60·3	15·66	14·51	12·76	11·26	9·78	9·21	8·32	7·59	6·96	6·38	5·60	5·11
2 1/2	63·5	16·35	15·16	13·34	11·78	10·25	9·64	8·72	7·95	7·30	6·69	5·88	5·36
2 5/8	66·7	17·05	15·81	13·92	12·29	10·70	10·07	9·11	8·31	7·63	7·00	6·15	5·62
2 3/4	69·8	17·74	16·46	14·50	12·81	11·16	10·51	9·51	8·67	7·97	7·31	6·43	5·87
2 7/8	73·0	18·43	17·10	15·08	13·33	11·62	10·94	9·90	9·04	8·30	7·62	6·70	6·12
3	76·2	19·12	17·75	15·66	13·85	12·08	11·37	10·30	9·40	8·64	7·93	6·98	6·37
3 1/4	82·5	20·51	19·05	16·82	14·89	12·99	12·24	11·09	10·13	9·31	8·55	7·52	6·87
3 1/2	88·9	21·89	20·34	17·98	15·92	13·91	13·11	11·88	10·86	9·98	9·17	8·07	7·38
3 3/4	95·2	23·28	21·64	19·14	16·96	14·82	13·97	12·67	11·58	10·65	9·79	8·62	7·88
4	101·6	24·66	22·94	20·29	18·00	15·74	14·84	13·46	12·30	11·32	10·41	9·17	8·38
4 1/4	107·9	26·04	24·23	21·45	19·03	16·65	15·70	14·25	13·03	11·99	11·03	9·72	8·89
4 1/2	114·3	27·43	25·53	22·61	20·07	17·57	16·57	15·04	13·75	12·66	11·65	10·27	9·39
4 3/4	120·6	28·81	26·82	23·77	21·11	18·48	17·43	15·83	14·48	13·34	12·27	10·82	9·89
5	127·0	30·20	28·12	24·93	22·14	19·40	18·30	16·62	15·21	14·01	12·89	11·36	10·40
5 1/4	133·3	31·58	29·42	26·09	23·18	20·31	19·17	17·41	15·93	14·68	13·50	11·91	10·[illegible]
5 1/2	139·7	32·97	30·71	27·25	24·22	21·23	20·03	18·20	16·66	15·35	14·12	12·46	11·[illegible]
5 3/4	146·0	34·35	32·01	28·40	25·26	22·14	20·90	18·99	17·38	16·02	14·74	13·01	11·[illegible]
6	152·4	35·73	33·30	29·56	26·29	23·06	21·76	19·78	18·11	16·69	15·36	13·56	12·4[illegible]
6 1/4	158·7	37·12	34·60	30·72	27·33	23·97	22·63	20·57	18·84	17·36	15·98	14·11	12·9[illegible]
6 1/2	165·1	38·50	35·90	31·88	28·36	24·89	23·50	21·36	19·56	18·03	16·60	14·66	13·4[illegible]

MANUFACTURED BY THE BROUGHTON COPPER CO.

OF COPPER

9	10	11	12	13	14	15	16	17	18	19	20	Wire Gauge	
0·148 9/64 F	0·134 9/64 B	0·120 1/8 B	0·109 7/64	0·095 3/32 F	0·083 5/64 F	0·072 5/64 B	0·065 1/16 F	0·058 1/16 B	0·049 3/64 F	0·042 3/64 B	0·035 1/32 F	Inches	
3·76	3·40	3·05	2·77	2·41	2·11	1·83	1·65	1·47	1·24	1·07	0·89	Millimeters	
FOOT IN POUNDS												Mm.	In.
0·49	0·42	0·36	0·31	0·25	0·21	0·17	0·15	0·13	0·10	0·09	0·07	3·2	1/8
0·72	0·63	0·54	0·48	0·40	0·34	0·28	0·25	0·22	0·18	0·15	0·12	6·3	1/4
0·94	0·83	0·72	0·64	0·54	0·46	0·39	0·35	0·31	0·25	0·21	0·17	9·5	3/8
1·17	1·04	0·91	0·81	0·69	0·59	0·50	0·45	0·39	0·33	0·28	0·23	12·7	1/2
1·39	1·24	1·09	0·98	0·83	0·72	0·61	0·55	0·48	0·40	0·34	0·28	15·9	5/8
1·62	1·44	1·27	1·14	0·98	0·84	0·72	0·65	0·57	0·48	0·41	0·33	19·0	3/4
1·84	1·65	1·46	1·31	1·12	0·97	0·83	0·75	0·66	0·55	0·47	0·39	22·2	7/8
2·07	1·85	1·64	1·47	1·27	1·10	0·94	0·84	0·75	0·63	0·53	0·44	25·4	1
2·30	2·06	1·82	1·64	1·41	1·22	1·05	0·94	0·84	0·70	0·60	0·49	28·6	1 1/8
2·52	2·26	2·00	1·81	1·56	1·35	1·16	1·04	0·92	0·77	0·66	0·55	31·7	1 1/4
2·75	2·46	2·19	1·97	1·70	1·48	1·27	1·14	1·01	0·85	0·73	0·60	34·9	1 3/8
2·97	2·67	2·37	2·14	1·85	1·60	1·38	1·24	1·10	0·92	0·79	0·65	38·1	1 1/2
3·20	2·87	2·55	2·31	1·99	1·73	1·49	1·34	1·19	1·00	0·85	0·71	41·3	1 5/8
3·42	3·08	2·74	2·47	2·14	1·86	1·60	1·44	1·28	1·07	0·92	0·76	44·4	1 3/4
3·65	3·28	2·92	2·64	2·28	1·98	1·71	1·54	1·37	1·15	0·98	0·81	47·6	1 7/8
3·87	3·49	3·10	2·80	2·43	2·11	1·82	1·64	1·45	1·22	1·05	0·87	50·8	2
4·10	3·69	3·28	2·97	2·57	2·24	1·93	1·74	1·54	1·30	1·11	0·92	54·0	2 1/8
4·33	3·89	3·47	3·14	2·72	2·36	2·04	1·84	1·63	1·37	1·18	0·97	57·1	2 1/4
4·55	4·10	3·65	3·30	2·86	2·49	2·15	1·93	1·72	1·45	1·24	1·03	60·3	2 3/8
4·78	4·30	3·83	3·47	3·01	2·62	2·26	2·03	1·81	1·52	1·30	1·08	63·5	2 1/2
5·00	4·51	4·02	3·64	3·15	2·74	2·36	2·13	1·90	1·60	1·37	1·13	66·7	2 5/8
5·23	4·71	4·20	3·80	3·30	2·87	2·47	2·23	1·98	1·67	1·43	1·19	69·8	2 3/4
5·45	4·91	4·38	3·97	3·44	3·00	2·58	2·33	2·07	1·74	1·50	1·24	73·0	2 7/8
5·68	5·12	4·57	4·13	3·59	3·12	2·69	2·43	2·16	1·82	1·56	1·29	76·2	3
6·13	5·53	4·93	4·47	3·88	3·38	2·91	2·63	2·34	1·97	1·69	1·40	82·5	3 1/4
6·58	5·94	5·30	4·80	4·17	3·63	3·13	2·83	2·51	2·12	1·82	1·51	88·9	3 1/2
7·03	6·34	5·66	5·13	4·46	3·88	3·35	3·03	2·69	2·27	1·95	1·61	95·2	3 3/4
7·48	6·75	6·03	5·46	4·75	4·14	3·57	3·22	2·87	2·42	2·07	1·72	101·6	4
7·93	7·16	6·40	5·80	5·04	4·39	3·79	3·42	3·05	2·57	2·20	1·83	107·9	4 1/4
8·38	7·57	6·76	6·13	5·33	4·61	4·01	3·62	3·22	2·71	2·33	1·93	114·3	4 1/2
8·83	7·98	7·13	6·46	5·62	4·90	4·23	3·82	3·40	2·86	2·46	2·04	120·6	4 3/4
9·28	8·39	7·49	6·79	5·91	5·15	4·45	4·02	3·57	3·01	2·59	2·15	127·0	5
9·74	8·79	7·86	7·13	6·20	5·40	4·67	4·22	3·75	3·16	2·71		133·3	5 1/4
10·19	9·20	8·22	7·46	6·49	5·66	4·89	4·41	3·93	3·31	2·84		139·7	5 1/2
10·64	9·61	8·59	7·79	6·78	5·91	5·11	4·61	4·10	3·46	2·97		146·0	5 3/4
11·09	10·02	8·96	8·12	7·07	6·16	5·33	4·81	4·28	3·61	3·10		152·4	6
11·54	10·43	9·32	8·46	7·36	6·42	5·54	5·01	4·46	3·76			158·7	6 1/4
11·99	10·84	9·69	8·79	7·65	6·67	5·76	5·21	4·63	3·91			165·1	6 1/2

WEIGHT OF SEAMLESS

Internal Diameter of Tubes (For External Diameter see foot-note.)		THICKNESS											
		0000	000	00	0	1	2	3	4	5	6	7	8
		0·454 29/64	0·425 27/64 F	0·380 3/8 F	0·340 11/32	0·300 19/64 F	0·284 9/32 F	0·259 1/4 F	0·238 15/64 F	0·220 7/32 F	0·203 13/64	0·180 3/17 B	0·165 11/64 B
		11·53	10·79	9·65	8·64	7·62	7·21	6·58	6·04	5·59	5·16	4·57	4·19
In.	Mm.	WEIGHT OF A LINEAL											
6¾	171·4	39·89	37·19	33·04	29·40	25·80	24·36	22·15	20·29	18·70	17·22	15·20	13·92
7	177·8	41·27	38·49	34·20	30·44	26·72	25·23	22·94	21·01	19·37	17·84	15·75	14·42
7¼	184·1	42·66	39·78	35·36	31·47	27·63	26·09	23·73	21·74	20·04	18·46	16·30	14·93
7½	190·5	44·04	41·08	36·51	32·51	28·55	26·96	24·52	22·46	20·72	19·08	16·85	15·43
7¾	196·8	45·42	42·38	37·67	33·55	29·46	27·83	25·31	23·19	21·39	19·69	17·40	15·93
8	203·2	46·81	43·67	38·83	34·58	30·38	28·69	26·10	23·92	22·06	20·31	17·95	16·44
8¼	209·5	48·19	44·97	39·99	35·62	31·29	29·56	26·89	24·64	22·73	20·93	18·49	16·94
8½	215·9	49·58	46·26	41·15	36·66	32·21	30·42	27·68	25·37	23·40	21·55	19·04	17·44
8¾	222·3	50·96	47·56	42·31	37·69	33·12	31·29	28·47	26·09	24·07	22·17	19·59	17·95
9	228·6	52·35	48·86	43·46	38·73	34·04	32·15	29·26	26·82	24·74	22·79	20·14	18·45
9¼	235·0	53·73	50·15	44·62	39·77	34·95	33·02	30·05	27·55	25·41	23·41	20·69	18·95
9½	241·3	55·11	51·45	45·78	40·80	35·87	33·89	30·84	28·27	26·08	24·03	21·24	19·46
9¾	247·7	56·50	52·74	46·94	41·84	36·78	34·75	31·63	29·00	26·75	24·65	21·79	19·96
10	254·0	57·88	54·04	48·10	42·88	37·70	35·62	32·42	29·72	27·42	25·27	22·33	20·46
10¼	260·4	59·27	55·34	49·26	43·90	38·61	36·48	33·21	30·45	28·09	25·89	22·88	20·97
10½	266·7	60·65	56·63	50·42	44·94	39·53	37·35	34·00	31·17	28·77	26·51	23·43	21·47
10¾	273·1	62·04	57·93	51·57	45·98	40·44	38·22	34·79	31·90	29·44	27·12	23·98	21·97
11	279·4	63·42	59·22	52·73	47·01	41·36	39·08	35·58	32·63	30·11	27·74	24·53	22·48
11¼	285·8	64·80	60·52	53·89	48·05	42·27	39·95	36·37	33·35	30·78	28·36	25·08	22·98
11½	292·1	66·19	61·82	55·05	49·09	43·19	40·81	37·16	34·08	31·45	28·98	25·62	23·48
11¾	298·5	67·57	63·11	56·21	50·12	44·10	41·68	37·95	34·80	32·12	29·60	26·17	23·99
12	304·8	68·96	64·41	57·37	51·16	45·02	42·55	38·74	35·53	32·79	30·22	26·72	24·49
12¼	311·2	70·34	65·70	58·53	52·20	45·93	43·41	39·53	36·25	33·46	30·83	27·27	24·99
12½	317·5	71·73	67·00	59·68	53·23	46·85	44·28	40·32	36·98	34·13	31·46	27·82	25·50
12¾	323·9	73·11	68·30	60·84	54·27	47·76	45·14	41·11	37·71	34·80	32·06	28·37	26·00
13	330·2	74·49	69·59	62·00	55·31	48·68	46·01	41·90	38·43	35·47	32·70	28·92	26·50
13¼	336·6	75·88	70·89	63·16	56·34	49·59	46·88	42·69	39·16	36·14	33·32	29·46	27·01
13½	342·9	77·26	72·18	64·32	57·38	50·51	47·74	43·48	39·88	36·82	33·94	30·01	27·51
13¾	349·3	78·65	73·48	65·48	58·42	51·42	48·61	44·27	40·61	37·49	34·56	30·56	28·01
14	355·6	80·03	74·78	66·63	59·45	52·34	49·47	45·06	41·34	38·16	35·17	31·11	28·52
		5·03	4·42	3·52	2·82	2·21	1·97	1·66	1·38	1·18	1·01	0·78	0·67

If the external diameter is given, subtract figure at bottom of column; for example, the weight per lineal foot of a copper tube 2" external diameter, 12 w.g., is 2·80−0·29=2·51 lbs.

To ascertain the weight of a seamless tube of other metal, multiply the weight of a similar copper tube by 0·95 for brass, by 0·86 for wrought iron, by 0·80 for cast iron, or by 1·27 for lead.

Copper Tubes, &c.—*continued.*

OF COPPER

9	10	11	12	13	14	15	16	17	18	19	20	Wire Gauge	
0·148 9/64 F	0·134 9/64 B	0·120 1/8 B	0·109 7/64	0·095 3/32 F	0·083 5/64 F	0·072 5/64 B	0·065 1/16 F	0·058 1/16 B	0·049 3/64 F	0·042 3/64 B	0·035 1/32 F	Inches	
3·76	3·40	3·05	2·77	2·41	2·11	1·83	1·65	1·47	1·24	1·07	0·89	Millimetres	
FOOT IN POUNDS												Mm.	In.
12·44	11·25	10·05	9·12	7·94	6·92	5·98	5·41	4·81	4·06			171·4	6¾
12·89	11·65	10·42	9·45	8·23	7·18	6·20	5·60	4·99	4·21			177·8	7
13·34	12·06	10·79	9·79	8·52	7·43	6·42	5·80	5·17				184·1	7¼
13·79	12·47	11·15	10·12	8·81	7·68	6·64	6·00	5·34				190·5	7½
14·25	12·88	11·52	10·45	9·10	7·94	6·86	6·20	5·52				196·8	7¾
14·70	13·29	11·88	10·78	9·39	8·19	7·08	6·40	5·70				203·2	8
15·15	13·70	12·25	11·12	9·68	8·44	7·30	6·60					209·5	8¼
15·60	14·10	12·61	11·45	9·97	8·69	7·52	6·79					215·9	8½
16·05	14·51	12·98	11·78	10·26	8·95	7·74	6·99					222·3	8¾
16·50	14·92	13·35	12·11	10·55	9·20	7·96	7·19					228·6	9
16·95	15·33	13·71	12·45	10·84	9·46	8·18						235·0	9¼
17·40	15·74	14·08	12·78	11·13	9·71	8·39						241·3	9½
17·85	16·15	14·44	13·11	11·42	9·96	8·61						247·7	9¾
18·30	16·55	14·81	13·44	11·71	10·22	8·83						254·0	10
18·75	16·96	15·18	13·78	12·00	10·47							260·4	10¼
19·21	17·37	15·54	14·11	12·29	10·72							266·7	10½
19·66	17·78	15·91	14·44	12·58	10·97							273·1	10¾
20·11	18·19	16·27	14·77	12·87	11·23							279·4	11
20·56	18·10	16·65	15·11	13·16								285·8	11¼
21·01	19·00	17·01	15·44	13·45								292·1	11½
21·46	19·41	17·37	15·77	13·74								298·5	11¾
21·91	19·82	17·74	16·10	14·03								304·8	12
22·36	20·23	18·10	16·44									311·2	12¼
22·81	20·64	18·47	16·77									317·5	12½
23·26	21·05	18·83	17·10									323·9	12¾
23·72	21·46	19·20	17·43									330·2	13
24·17	21·86	19·57										336·6	13¼
24·62	22·27	19·93										342·9	13½
25·07	22·68	19·80										349·3	13¾
25·52	23·09	20·66										355·6	14
0·53	0·43	0·35	0·29	0·22	0·17	0·13	0·11	0·08	0·06	0·05	0·03		

Decimal Equivalents of Inches and Feet

1/8	=	·01041
1/4	=	·02083
3/8	=	·03125
1/2	=	·04166
5/8	=	·05208
3/4	=	·06250
7/8	=	·07291
1	=	·08333
2	=	·16666
3	=	·25000
4	=	·33333
5	=	·41666
6	=	·50000
7	=	·58333
8	=	·66666
9	=	·75000
10	=	·83333
11	=	·91666
12	=	1·00000

Brazed copper tubes weigh more per lineal foot than seamless; but an exact constant multiple cannot be given, as the proportion of difference in weight varies with the thickness, the diameter, and the class of joint of the brazed tube. Mandrildrawn brazed tubes weigh the same as seamless tubes.

The above weights are theoretically correct; but in practice a slight deviation from the theoretical weight must be expected. F, full. B, bare.

VICKERS, SONS & MAXIM'S, LTD., GUNS AND MOUNTINGS.

	—	101·6 mm. 45 cal.	101·6 mm. 50 cal.	12 cm. 40 cal.	12 cm. 45 cal.	15·24 cm. 40 cal.
Gun	Diameter of bore (in inches)	4	4	4·724	4·724	6
	Length of bore (in inches)	180	200	189·98	212·58	240
	Total length of gun (in inches)	188·1	206	193·28	217	249·2
	Diameter of chamber	5	5	5·1	5·5	6·8
	Length of chamber	21·2	21·2	25·5	25·75	32·5
	Maximum pressure in chamber	17 tons	17 tons	16 tons	17 tons	16 tons
		Cordite	Cordite	Cordite	Cordite	Cordite
		6 lbs.	6 lbs.	8·5 lbs.	9 lbs.	19 lbs.
		25 lbs.	25 lbs.	45 lbs.	45 lbs.	100 lbs.
	including breech	Tons Cwt. Qrs. 1 13 0	Tons Cwt. Qrs. 1 16 0	Tons Cwt. Qrs. 2 10 0	Tons Cwt. Qrs. 3 14 0	Tons Cwt. Qrs. 6 15 0
	second	2,700	2,800	2,494	2,600	2,580
		1,263	1,359	1,940	2,108	4,437
	on plate at muzzle	11·6	12·3	13·3	14·1	18·6
	Penetration of steel plate at muzzle by Gavre's formula	9	9·5	10·3	10·9	14·4
	Rounds per minute	15	15	12	12	8
Mounting	Weight of mounting, complete with shield	Tons Cwt. Qrs. 4 4 3	Tons Cwt. Qrs. 4 10 0	Tons Cwt. Qrs. 5 17 0	Tons Cwt. Qrs. 6 5 0	Tons Cwt. Qrs. 8 15 0
	Thickness of shield (in inches)	4	4	4	4	4
	Weight of shield	Tons Cwt. Qrs. 2 6 0	Tons Cwt. Qrs. 2 6 0	Tons Cwt. Qrs. 3 18 0	Tons Cwt. Qrs. 3 18 0	Tons Cwt. Qrs. 4 0 0
	Angle of elevation	20°	20°	20°	20°	15°
	Angle of depression	7°	7°	7°	7°	7°

Older types of 9·2 in., 10 in., 12 in., and 13·5 in. guns, as manufactured by Vickers, Sons & Maxim, Ltd., are not enumerated in the table, but only modern guns making use of smokeless powders.

VICKERS, SONS & MAXIM'S, LTD., GUNS AND MOUNTINGS.

	—	15·24 cm. 45 cal.	* 20·3 cm. 45 cal.	* 23·36 cm. 45 cal.	* 25·4 cm 42 cal.	* 30·48 cm. 40 cal.
Gun	bore (in inches)	6	8	9·2	10	12
	ore (in inches)	270	360	414	405·15	480
	Total length of gun (in inches)	279·2	372·1	425·8	490	496·5
	Diameter of chamber	9·5	11	13·5	11·5	17·5
	Length of chamber	33	43	67	65·35	67·2
	Maximum pressure in chamber	17 tons	17 tons	17 tons	17 tons	17 tons
	Nature of charge	Cordite	Cordite	Cordite	Cordite	Cordite
	Weight of charge	25 lbs.	50 lbs.	94·5 lbs.	100 lbs.	207 lbs.
	Weight of projectile	100 lbs.	250 lbs.	380 lbs.	460 lbs.	850 lbs.
	Total weight of gun, including breech mechanism	Tons Cwt. Qrs. 7 8 0	Tons Cwt. Qrs. 18 16 2	Tons Cwt. Qrs. 26 18 0	Tons Cwt. Qrs. 28 4 0	Tons Cwt. Qrs. 50 7 0
	Muzzle velocity in feet per second	2,775	2,625	2,750	2,580	2,600
	Muzzle energy in foot-tons	5,340	11,945	19,927	20,811	39,843
	Penetration of wrought iron plate at muzzle by Gavre's formula	21·1	27·6	34·3	32·3	43·3
	Penetration of steel plate at muzzle by Gavre's formula	16·4	21·4	26·6	25·0	33·6
	Rounds per minute	6	5			
Mounting	Weight of mounting, complete with shield	Tons Cwt. Qrs. 9 5 0	Tons Cwt. Qrs. 16 8 0	Depending on type of mounting used.		
	Thickness of shield (in inches)	4	4			
	Weight of shield	Tons Cwt. Qrs. 4 0 0	Tons Cwt. Qrs. 7 0 0			
	Angle of elevation	16°	15°			
	Angle of depression	7°	5°			

* Under manufacture.

Older types of 9·2 in., 10 in., 12 in., and 13·5 in. guns, as manufactured by Vickers, Sons & Maxim, Ltd., are not enumerated in the table, but only modern guns making use of smokeless powders.

SCHNEIDER-CANET QUICK-FIRE GUNS.

Calibre in centimetres	24		20			15·94		15			14	12			
Calibre in ins.	9·45		7·87			6		5·91			5·5	4·72			
		*		*		*	*	*	*	*	*	*	*	*	*
Length in calibres	40	45	40	45	50	45	50	40	45	50	45	30	40	45	50
Length in ft.	31·5	35·4	26·2	29·5	32·7	25	27	19·6	22·6	24·6	20·6	11·8	16·7	17·7	19·7
Weight of gun in tons	21·45	23·73	11·61	13·18	14·96	5·65	6·08	4·72	5·61	6·20	4·72	1·61	2·36	2·75	3
	331	331	198	198	198	94·9	94·9	88·2	88·2	88·2	88·2	39·7	46·3	46·3	46·3
	2690	2790	2630	2760	2860	2670	2750	2560	2660	2740	2670	1970	2630	2630	2710
	16612	17638	9484	10450	11258	4569	4959	4000	4330	4590	3143·2	1114	2048	2216	2348
n ft.-secs.	2075	2147	1944	2039	2111	1860	1900	1744	1813	1858	1690	1170	1681	1645	1691
ft.-tons	9900	10600	5260	5750	6120	2264	2399	1860	2000	2150	1739	387	900	870	955
Perforation at muzzle, Gavre formula, in ins.	34·1	36·04	27·3	29·6	31·1	22·2	23·3	19·6	20·8	21·8	19·3	9·7	15·1	16·2	16·8
Perforation at muzzle, Tresidder formula, through wrought iron, in ins.	31·3	33·1	25·6	27·5	29·0	21·0	22·0	19·1	20·2	21·0	17·6	10·4	15·2	16·1	16·8
Perforation at 2,000 metres, in ins.	22·9	24	17·2	18·5	19·5	12·7	13·3	10·9	11·5	12·1	12·4	4·3	6·5	6·7	6·9

Calibre in centimetres	10			9	7·5			6·5			5·7		4·7	3·7
Calibre in ins.	3·94			3·5	2·95			2·57			2·24		1·85	1·46
	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Length in calibres	45	50	60	30	45	50	60	45	50	60	50	60	60	60
Length in ft.	14·8	16·4	19·7	8·8	11·04	12·3	14·8	9·59	10·65	12·8	9·34	11·2	9·24	7·27
Weight of gun in tons	1·69	1·88	2·18	0·71	0·9	0·88	1·06	0·49	0·54	0·69	0·45	0·50	0·26	0·14
Weight of projectile in lbs.	28·6	28·6	28·6	16·7	13·2	13·2	13·2	9·8	9·8	9·8	5·9	5·9	3·3	1·7
Muzzle velocity in ft.-secs.	2490	2630	2820	1970	2430	2530	2760	2360	2459	2721	2426	2721	2666	2622
	1235	1367	1587	451	540	587	696	342	372	456	242	307	167	84·5
n ft.-secs.	1475	1557	1672	1020	1291	1337	1462	1167	1208	1327	1101	1209	1045	820
ft.-tons	439	485	560	121	155	165	197	83·5	90	106	51	60	25	8·3
avre formula, in	12·6	13·7	15·3	7·4	9·3	9·99	11·3	7·75	8·3	9·4	6·95	8·30	6·4	5·08
esidder formula, n ins.	12·7	13·6	15·3	7·2	9·4	10·1	11·5	8·5	9·0	10·5	7·3	8·7	—	—
s in ins.	5·05	6·16	6·5	3·10	3·66	3·75	4·3	2·69	2·78	3·3	2·06	2·3	1·5	0·66

* Guns in actual use.

KRUPP QUICK-FIRE GUNS, MODEL 1899.—LIGHT GUNS.

Calibre in centimetres		7·5			10·5			12			15	
Calibre in ins.		2·95			4·13			4·72			5·91	
Total length of gun in calibres	40	45	50	40	45	50	40	45	50	40	45	50
Total length in ft.	9·84	11·07	12·30	13·78	15·5	17·22	15·75	17·7	19·69	19·55	22·0	24·46
Length of bore in ins.	108·66	123·43	138·19	153·55	174·21	194·89	175·20	199·25	222·45	218·12	247·49	276·78
Weight of piece in lbs.	1488·2	1710·8	1935·7	4078	4740	5318	6107	7055	7987	11707	13448	15212
Weight of piece in tons	0·66	0·76	0·86	1·82	2·12	2·37	2·73	3·15	3·54	5·23	6·0	6·79
Weight of steel projectile in lbs.	11·5	11·5	11·5	30·86	30·86	30·86	46·30	46·30	46·30	90·39	90·39	90·39
	14·6	14·6	14·6	39·68	39·68	39·68	59·52	59·52	59·52	112·4	112·4	112·4
Weight of charge in lbs.	2·78	3·13	3·55	8·37	9·49	10·75	12·21	14·31	16·56	23·42	27·44	31·76
Muzzle velocity in ft.-secs.	2690	2890	3067	2720	2920	3097	2766	2982	3199	2720	2936	3143
	2388	2565	2723	2395	2577	2733	2438	2631	2822	2438	2631	2822
Muzzle energy in ft.-tons	575·7	664·8	748·6	1581	1826	2056	2453	2856	3285	4631	5389	6196
Perforation thro' steel in ins.	7·12	7·91	8·62	10·2	11·3	12·3	12·1	13·4	15·0	15·2	16·9	18·7
Perforation thro' iron, Tresidder's formula	9·8	11·0	11·8	13·5	15·2	16·5	16·2	18·2	20·1	20·1	22·5	25·0
Calibre in centimetres		21			24			28			30·5	
Calibre in ins.		8·27			9·45			11·02			12·01	
Total length of gun in calibres	40	45	50	40	45	50	40	45	50	40	45	50
Total length in ft.	27·56	30·9	34·45	31·50	35·4	39·37	36·75	41·3	45·93	40·03	45·0	50·03
Length of bore in ins.	305·91	347·29	388·59	350·80	398·28	445·28	409·46	464·62	519·7	445·67	505·95	565·76
Weight of piece in lbs.	32294	37254	41890	48722	56222	63273	77603	89062	100974	100812	115081	130290
Weight of piece in tons	14·42	16·63	18·70	21·75	25·10	28·25	34·65	39·76	45·08	44·78	51·14	58·17
Weight of steel projectile in lbs.	249·1	249·1	249·1	374·8	374·8	374·8	595·2	595·2	595·2	771·6	771·6	771·6
	308·6	308·6	308·6	474·0	474·0	474·0	760·6	760·6	760·6	981·0	981·0	981·0
Weight of charge in lbs.	64·55	75·64	87·55	97·35	114·09	132·0	152·2	181·88	210·5	200·4	234·79	271·7
Muzzle velocity in ft.-secs.	2776	2995	3215	2805	3025	3248	2818	3038	3264	2812	3035	3255
	2494	2690	2887	2494	2690	2887	2494	2690	2887	2494	2690	2887
Muzzle energy in ft.-tons	13296	15490	17845	20427	23783	27397	32786	38143	43952	42274	49812	56666
Perforation thro' steel in ins.	22·8	24·9	27·6	26·5	29·2	32·4	31·5	34·7	38·5	34·5	38·0	42·0
Perforation thro' iron, Tresidder's formula	28·9	32·1	36·0	33·4	37·4	41·9	39·1	44·0	49·0	42·8	47·8	53·5

NOTE.—Every one of the guns included in the tables has been actually constructed, and can be supplied on order.

KRUPP QUICK-FIRE GUNS, MODEL 1899.—HEAVY GUNS.

Calibre in centimetres	7·5			10·15			12			15		
Calibre in ins.	2·95			4·13			4·72			5·91		
Total length of gun in cals.	40	45	50	40	45	50	40	45	50	40	45	50
Total length in ft.	9·84	11·07	12·30	13·78	15·5	17·22	15·75	17·7	19·69	19·55	22·0	24·46
Length of bore in ins.	108·66	123·48	138·19	153·55	174·21	194·89	175·20	199·25	222·45	218·12	247·49	276·78
Weight of piece in lbs.	1860·7	2094·3	2325·9	5115	5732	6393	6680	7628	8598	12787	14661	16535
Weight of piece in tons	0 83	0·93	1·04	2·28	2·56	2·85	2·98	3·41	3·84	5·74	6·55	7·38
Weight of steel projectile in lbs.	11·5	11·5	11·5	30·86	30·86	30·86	46·30	46·30	46·30	90·39	90·39	90·39
	14·6	14·6	14·6	39·68	39·68	39·68	59·52	59·52	59·52	112·4	112·4	112·4
Weight of charge in lbs.	3·0	3·35	3·77	9·22	10·41	12·02	14·11	15·72	18·50	27·07	30·16	35·49
Muzzle velocity in ft.-secs.	2792	2975	3159	2917	3130	3330	2938	3143	3350	2891	3091	3294
	2476	2641	2805	2572	2760	2940	2585	2772	2953	2592	2772	2953
Muzzle energy in ft.-tons	619·6	708·5	794·8	1820	2094	2375	2759	3172	3598	5228	6002	6809
Perforation thro' steel in ins.	7·52	8·22	8·97	11·3	12·5	13·7	13·2	14·6	16·0	16·5	18·2	19·6
Perforation thro' iron, Tresidder's formula	10·5	11·4	12·3	15·3	17·0	19·0	17·8	19·7	21·7	22·0	24·3	26·9

Calibre in centimetres	21			24			28			30·5		
Calibre in ins.	8·27			9·45			11·02			12·01		
Total length of gun in cals.	40	45	50	40	45	50	40	45	50	40	45	50
Total length in ft.	27·56	30·9	34·45	31·50	35·40	39·37	36·75	41·3	45·93	40·03	45·0	50·3
Length of bore in ins.	305·91	347·29	388·59	350·80	398·28	445·28	409·46	464·62	519·70	445·67	505·95	565·76
Weight of piece in lbs.	35270	40341	45418	53241	60843	68340	84882	97000	109182	109578	125224	140874
Weight of piece in tons	15·75	18·01	20·27	23·32	27·16	30·51	37·89	43·30	48·72	48·92	55·90	62·44
Weight of steel projectile in lbs.	249·1	249·1	249·1	374·8	374·8	374·8	595·2	595·2	595·2	771·6	771·6	771·6
	308·6	308·6	308·6	474	474	474	760·6	760·6	760·6	981·0	981·0	981·0
Weight of charge in lbs.	74·65	88·11	97·84	112·6	125·36	147·6	179·45	199·82	235·2	231·66	257·96	303·7
Muzzle velocity in ft.-secs.	2884	3087	3288	2913	3117	3320	2913	3123	3324	2910	3120	3320
	2592	2772	2953	2592	2772	2953	2576	2766	2940	2582	2766	2940
Muzzle energy in ft.-tons	14360	16458	18652	22078	25171	28656	35078	40305	45630	45340	52084	58957
Perforation thro' steel in ins	23·6	26·3	28·4	27·7	30·6	33·7	32·7	36·2	39·5	35·9	39·7	43·3
Perforation thro' iron, Tresidder's formula	30·5	33·5	37·0	35·5	39·1	43·2	40·8	45·4	49·8	45·4	50·0	54·5

NOTE.—Every one of the guns included in the tables has been actually constructed and can be supplied on order.

Legal Standard Wire Gauge.

Descriptive Number	Equivalents in Parts of an Inch	Metric Equivalent in Millimetres	Descriptive Number	Equivalents in Parts of an Inch	Metric Equivalent in Millimetres
No. 7/0	0·500	12·700	No. 23	0·024	0·610
6/0	·464	11·785	24	·022	·559
5/0	·432	10·973	25	·020	·508
4/0	·400	10·160	26	·018	·457
3/0	·372	9·449	27	·0164	·4166
2/0	·348	8·839	28	·0148	·3759
0	·324	8·229	29	·0136	·3454
1	·300	7·620	30	·0124	·3150
2	·276	7·010	31	·0116	·2946
3	·252	6·401	32	·0108	·2743
4	·232	5·893	33	·0100	·2540
5	·212	5·385	34	·0092	·2337
6	·192	4·877	35	·0084	·2134
7	·176	4·470	36	·0076	·1930
8	·160	4·064	37	·0068	·1727
9	·144	3·658	38	·0060	·1524
10	·128	3·251	39	·0052	·1321
11	·116	2·946	40	·0048	·1219
12	·104	2·642	41	·0044	·1118
13	·092	2·337	42	·0040	·1016
14	·080	2·032	43	·0036	·0914
15	·072	1·829	44	·0032	·0813
16	·064	1·626	45	·0028	·0711
17	·056	1·422	46	·0024	·0610
18	·048	1·219	47	·0020	·0508
19	·040	1·016	48	·0016	·0406
20	·036	0·914	49	·0012	·0305
21	·032	·813	50	·0010	·0254
22	·028	·711			

TABLE OF WEIGHT AND STRENGTH OF STEEL WIRE.

Standard Wire Gauge	Diameter		Sectional Area	Weight of 100 Yards	Weight of 1 Mile	Approximate Length of 1 Cwt.	Breaking Strain if tempered to 100 Tons per Square Inch	Standard Wire Gauge
	Inch	Mm.	Square Inch	Lbs.	Lbs.	Yards	Lbs.	
7/0	·500	12·7	·1963	193·4	3,404	58	43,975	7/0
6/0	·464	11·8	·1691	166·5	2,930	67	37,854	6/0
5/0	·432	11·0	·1466	144·4	2,541	78	32,823	5/0
4/0	·400	10·2	·1257	123·8	2,179	91	28,144	4/0
3/0	·372	9·4	·1087	107·1	1,885	105	24,354	3/0
2/0	·348	8·8	·0951	93·7	1,649	120	21,302	2/0
0	·324	8·2	·0824	81·2	1,429	138	18,464	0
1	·300	7·6	·0707	69·6	1,225	161	15,831	1
2	·276	7·0	·0598	58·9	1,037	190	13,398	2
3	·252	6·4	·0499	49·1	864	228	11,169	3
4	·232	5·9	·0423	41·6	732	269	9,467	4
5	·212	5·4	·0353	34·8	612	322	7,904	5
6	·192	4·9	·0290	28·5	502	393	6,486	6
7	·176	4·5	·0243	24·0	422	467	5,450	7
8	·160	4·1	·0201	19·8	348	566	4,503	8
9	·144	3·7	·0163	16·0	282	700	3,648	9
10	·128	3·3	·0129	12·7	223	882	2,882	10
11	·116	3·0	·0106	10·4	183	1,077	2,368	11
12	·104	2·6	·0085	8·4	148	1,333	1,903	12
13	·092	2·3	·0066	6·5	114	1,723	1,489	13
14	·080	2·0	·0050	5·0	88	2,240	1,126	14
15	·072	1·8	·0041	4·0	70	2,800	912	15
16	·064	1·6	·0032	3·2	56	3,500	721	16
17	·056	1·4	·0025	2·4	42	4,667	552	17
18	·048	1·2	·0018	1·8	32	6,222	406	18
19	·040	1·0	·0013	1·2	21	9,333	281	19
20	·036	·9	·0010	1·0	18	11,200	228	20

Comparison of Numbers of the Principal Plate Gauges.

Whitworth's Decimal Gauge, 1,000-ths of an Inch	Corresponding Numbers of the Old			Whitworth's Decimal Gauge, 1,000-ths of an Inch	Corresponding Numbers of the Old		
	Birmingham Wire Gauge	Birmingham Plate Gauge	Lancashire Gauge		Birmingham Wire Gauge	Birmingham Plate Gauge	Lancashire Gauge
1	—	—	—	50	18	16	55
2	—	—	—	55	—	17*	54
3	—	—	—	60	17*	18	52
4	36	1	—	65	16	19	51
5	35	2	—	70	15*	21*	49
6	—	—	—	75	—	22	47
7	34	—	—	80	—	24*	45
8	33	3	—	85	14*	—	43
9	32	—	—	90	—	—	42
10	31	4	—	95	13	25	41
11	—	—	—	100	—	26**	38
12	30	5	—	110	12	27**	34
13	29	6	80	120	11	28	31*
14	28	—	79	135	10	31*	29
15	—	7	78	150	9*	34*	23
16	27	8	77	165	8	36*	19
17	—	—	—	180	7	—	13
18	26	—	76	200	6**	—	5**
19	—	9	—	220	5	—	2
20	25	—	75	240	4*	—	C*
22	24	—	74	260	3	—	G
24	23*	10	72	280	2**	—	K
26	—	—	71	300	1	—	N*
28	22	11	70	325	—	—	P*
30	—	—	68	350	—	—	S*
32	21	—	66	375	00**	—	V*
34	—	12	64	400	—	—	X**
36	20	13	62	425	000	—	—
38	—	—	61	450	0000**	—	—
40	19*	14	59	475			
45	—	15*	56	500			

Note.—Sizes which differ from those in the first column by more than ·002 of an inch are marked thus **; those of which the difference exceeds ·001, thus *. All others either correspond exactly, or are within ·001 of an inch.

RIVETED JOINTS, &c.

FORMULA FOR RIVETED JOINTS.

d = diameter of rivets in inches.
p = pitch of rivets in inches.
t = thickness of plates in inches.

$\int_t$ = tenacity of plates in tons per square inch.

n = number of rows of rivets.

$\int_t$ = (Iron) $\begin{cases} \text{22 for unpunched.} \\ \text{20 for punched about 8 diameters pitch.} \\ \text{18 for punched about 4 diameters pitch.} \end{cases}$

$\int_t$ = (Steel) $\begin{cases} \text{28 for unpunched.} \\ \text{26 for punched at about 8 diameter pitch.} \\ \text{24 for punched at about 4 diameters pitch.} \\ \text{28 for drilled holes and the same punched } \tfrac{1}{8} \text{ small and} \\ \quad \text{countersunk through the plate.} \end{cases}$

$\int_s$ = shearing resistance of rivets in tons per square inch.

For iron rivets = 22 tons per square inch.
For steel rivets = 26 tons per square inch.

$n \times \frac{\pi d^2}{4} \times \int_s$ = shearing resistance of rivets in tons,

should $= \int_t (p-d)\, t$ = strength of strip of width p after punching in order that the rivet should be on the point of shearing as the plate is on the point of tearing.

$$p = \frac{\pi d^2 \times \int_s \times n}{4 \times \int_t \times t} + d$$

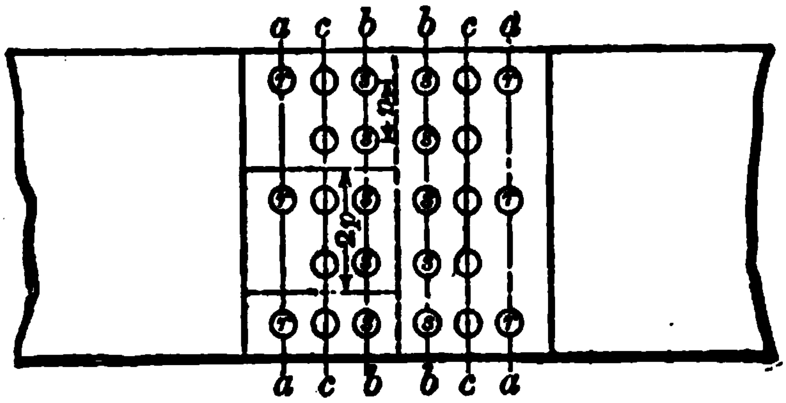
$$n = \frac{4 \int_t t\,(p-d)}{\pi d^2 \times \int_s}$$

$$t = \frac{\pi d^2 \times \int_s \times n}{4 \times \int_t (p-d)}$$

Note.—In double butt straps the shearing resistance of the rivets is doubled.

Treble riveted butt connections may be broken in five different ways, see fig. 197.

FIG. 197.



(1) The plate may break through the line *a a*.

(2) The strap may break through the line *b b*.

(3) The plate may break through the line *c c* and shear rivets *r*, *r*.

(4) The butt strap may break through line *c c* and shear rivets *s*, *s*.

(5) All rivets may shear on one side of butt strap.

The strengths of a width equal to twice the pitch.

(1) $\int_t t\,(2p-d)$;

(2) $\frac{9}{8}\int t\,(2p-2d)$;

(3) $\int t\,(2p-2d) + \left(\frac{\pi d^2}{4}\int_s\right)$;

(4) $\frac{9}{8}\int_t t\,(2p-2d) + \left(\frac{\pi d^2}{4}\int_s\right)2$;

(5) $$\frac{\pi d^2 \times \int_s \times 5}{4}.$$

Note.—The thickness of strap is taken as $\frac{1}{8}$ inch thicker than the plate.

Ordinary Proportions of Riveted Joints.

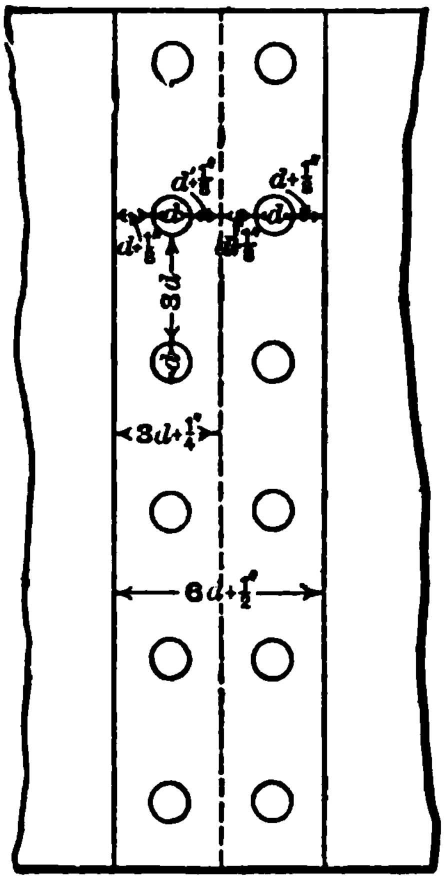


Fig. 198.
Single riveted butt.

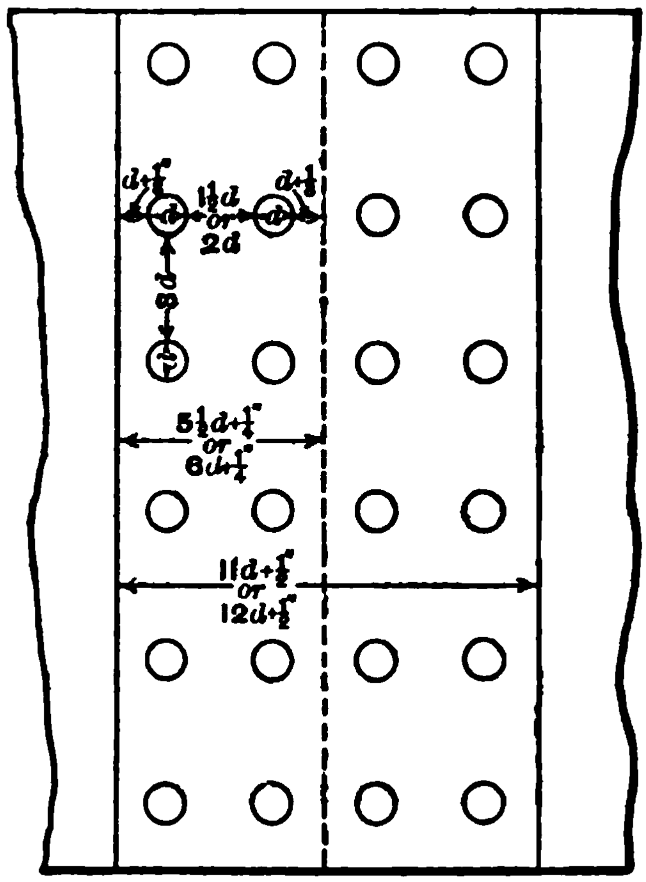
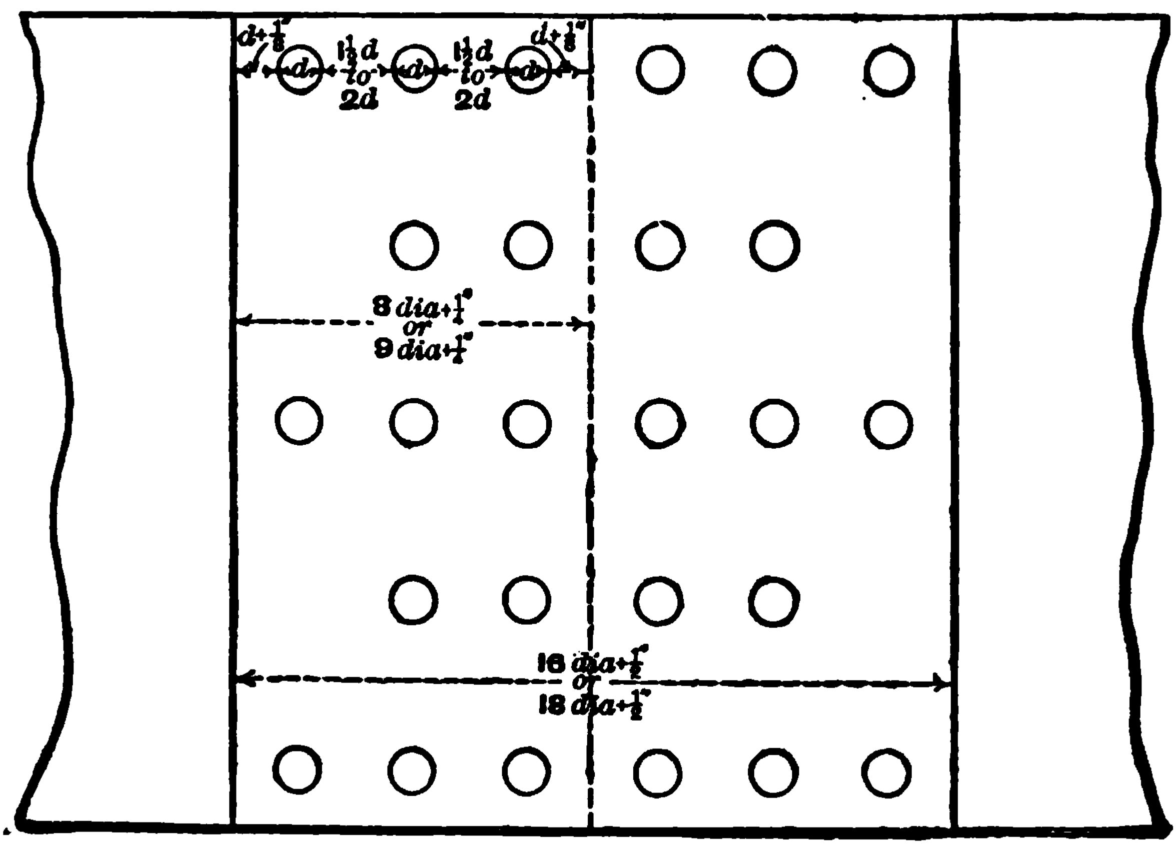


Fig. 199.
Double chain riveted butt.

Fig. 200.—Treble chain riveted butt.



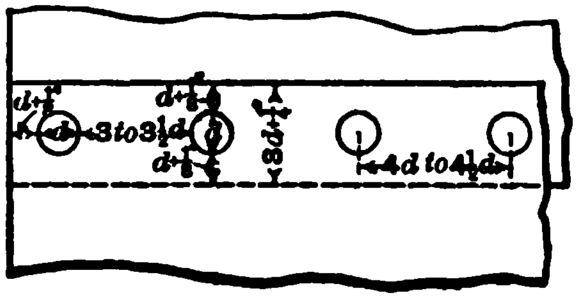


FIG. 201.
Single riveted seam.

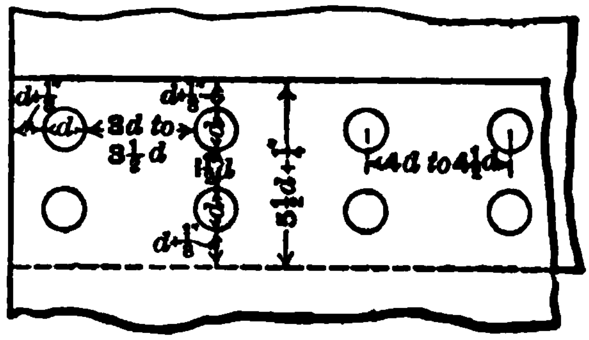
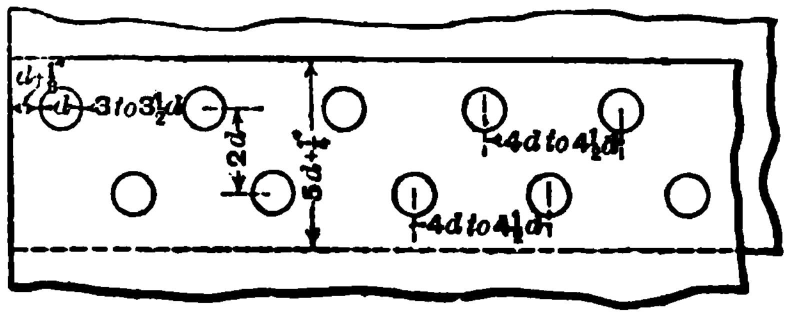


FIG. 202.
Chain riveted seam.

FIG. 203.—Zigzag seam.



RIVETED JOINTS.

General Notes on Ship Butt Connections for Stringers, &c.

In a stringer plate the butt connections should be made equal to the strength of the plate through a line of holes at a beam. The total shearing resistance of the rivets on one side of butt should equal the tensile strength of the plate through the line of rivet holes farthest from the butt.

The tensile strength of a butt strap through the line of rivet holes nearest the butt should equal the strength of the plate through the line of rivet holes farthest from the butt.

Rivets should never be nearer the edge than their diameter plus $\frac{1}{8}$ of an inch.

Rivets should never exceed twice the thickness of the plate.

Double butt straps $\frac{1}{16}$ inch to $\frac{1}{8}$ inch thicker than half the thickness of one plate give double shear to the rivets, provided the diameter of the rivet does not exceed twice the thickness of the plate.

In treble or quadruple riveted straps the alternate rivet should always be left out in the rows nearest to and farthest from the butt; provided there is sufficient shearing strength for the rivets, and the joint is not to be watertight, the butt strap may then be only the same thickness as the plate.

If the butt is watertight, only the alternate rivet in the row farthest from the butt should be left out, and the butt strap made thicker to suit.

The strength of a riveted joint cannot exceed the strength of the plate through the line of rivet holes farthest from the butt.

In the joints (figs. 204 and 205) the strength of plate is only weakened by the extent of one rivet hole. Double butt straps should be fitted.

FIG. 204.

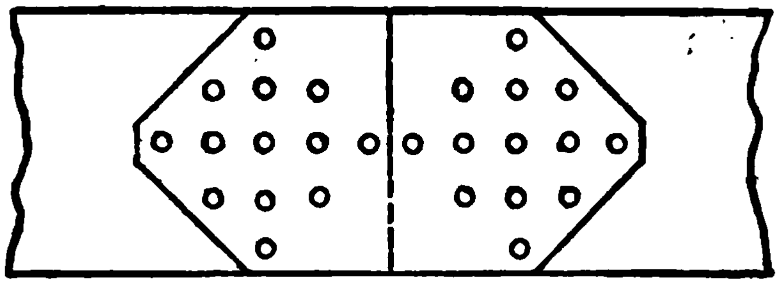
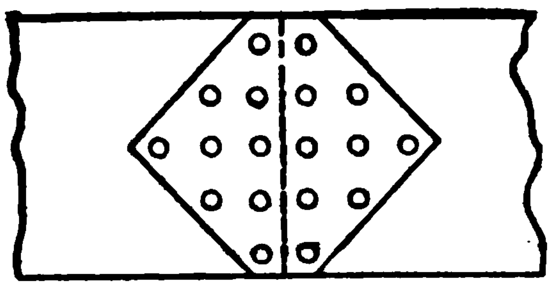


FIG. 205.



RELATION OF FRAME-SPACE AND SHIFT OF BUTTS TO THE BUTT FASTENINGS OF SKIN PLATING.

(From *Transactions of Institution of Naval Architects*, 1873.)

Calculate the strength of the necessarily weakened section of the butted plate, say of F F (see fig. 206).

Calculate the shearing strength of the edge rivets between the butt and this weakened section.

The difference between these two results fixes the minimum shearing strength of the rivets required to be worked on each side of the butt, and if their size is fixed this determines their number.

Having determined the number of rivets required on each side of the butt, it lastly becomes necessary to determine how they shall be disposed, the main rule to be observed being that no specially weak line shall be caused, either in the plate or the butt strap. The line P P on the strake B (fig. 206) is such a line; and as the necessity for ensuring watertightness renders a close pitch of rivet essential in the row nearest the butt, that line is a specially weak one for both plate and strap.

It appears that, so far as tensile strength is concerned, the use of long plates is not specially advantageous, except when the frame-space is unusually great, say from 5 or 6 feet upwards.

The frame-space, regulating as it does the amount of succour which passing strakes can give to butted strakes, practically governs the arrangement of the butt fastenings, and affords a means of determining upon a suitable shift of butts. An increase

Fig. 206.

in the spacing of the transverse frames favours the more satis factory development of the strength of the skin plating.

TABLE OF MR. FAIRBAIRN'S PROPORTIONS FOR RIVETED JOINTS FROM EXPERIMENTS.

Thickness of Plate in Inches	Diameter of Rivets in Inches		Length of Rivet from the Head in Inches		Distance of Rivets from Centre to Centre		Quantity of Lap in Single Joints in Inches		Quantity of Lap in Double Riveted Joints in Inches
·19 = $\frac{3}{16}$	·38	2 diams.	·88	$4\frac{1}{2}$ diams.	1·25	6 diams.	1·25	6 diams.	For the double joints add two-thirds of the depth of single lap.
·25 = $\frac{1}{4}$	·50		1·13		1·50		1·50		
·31 = $\frac{5}{16}$	·63		1·38		1·63	5 diams.	1·88		
·38 = $\frac{6}{16}$	75		1·63		1·75		2·00	$5\frac{1}{2}$ diams.	
·50 = $\frac{8}{16}$	·81	$1\frac{1}{2}$ diam.	2·25		2·00	4 diams.	2·25	4·5 diams.	
·63 = $\frac{10}{16}$	·94		2·75		2·50		2·75		
·75 = $\frac{12}{16}$	1·13		3·25		3·00		3·25		

Lloyd's Diameters and Spacing of Rivets, &c., in Iron Plating.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins
Thickness of plates	$\frac{5}{16}$	$\frac{6}{16}$	$\frac{6}{16}$ & $\frac{7}{16}$ alternately	$\frac{7}{16}$	$\frac{8}{16}$	$\frac{9}{16}$	$\frac{9}{16}$ & $\frac{10}{16}$ alternately	$\frac{10}{16}$ *	$\frac{11}{16}$	$\frac{12}{16}$	$\frac{12}{16}$ & $\frac{13}{16}$ alternately	$\frac{13}{16}$	$\frac{14}{16}$	$\frac{15}{16}$	$\frac{16}{16}$
Diameter of rivets	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1	$1\frac{1}{8}$	$1\frac{1}{8}$
Breadth of treble riveted straps	—	—	—	—	$14\frac{1}{4}$	$14\frac{1}{4}$	$14\frac{1}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	19	19	19	$21\frac{1}{4}$	$21\frac{1}{4}$
" " double " "	8	8	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	—	—	—	—	—
" " treble " butt laps	—	—	—	—	$7\frac{1}{2}$	$7\frac{1}{2}$	$7\frac{1}{2}$	9	9	9	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$	—	—
" " double " " "	$4\frac{1}{4}$	$4\frac{1}{4}$	5	5	5	5	5	6	6	6	—	—	—	—	—
" " double " edge laps	$3\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	6	6	6	$6\frac{3}{4}$	$6\frac{3}{4}$
" " single " " "	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	—	—	—	—	—	—	—	—	—	—
Maximum spacing of rivets from centre to centre: in butts of outside plating	$2\frac{1}{2}$	$2\frac{1}{2}$	3	3	3	3	3	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$
in edges " "	$2\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	4	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	5	5
in frames " "	5	5	6	6	6	6	6	7	7	7	8	8	8	—	—

* Where stringer and tie plates are $\frac{10}{16}$ of an inch thick, they should be secured to the beams with $\frac{3}{4}$ inch rivets.

Lloyd's Diameters and Spacing of Rivets, &c., in Steel Plating.

	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Thickness of plates	$\frac{5}{20}$	$\frac{6}{20}$	$\frac{6}{20}$ & $\frac{7}{20}$	$\frac{7}{20}$	$\frac{8}{20}$	$\frac{9}{20}$	$\frac{9}{20}$ & $\frac{10}{20}$	$\frac{10}{20}$	$\frac{11}{20}$	$\frac{12}{20}$	$\frac{12}{20}$ & $\frac{13}{20}$	$\frac{13}{20}$	$\frac{14}{20}$	$\frac{14}{20}$ & $\frac{15}{20}$	$\frac{15}{20}$	$\frac{16}{20}$
Diameter of rivets	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	1	1	1	1
Breadth of treble riveted straps	—	—	—	—	$14\frac{1}{4}$	$14\frac{1}{4}$	$14\frac{1}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	$16\frac{3}{4}$	19	19	19	19
" " double " "	8	8	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$9\frac{3}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	$11\frac{1}{4}$	—	—	—	—
" " treble " butt laps	—	—	—	—	$7\frac{1}{2}$	$7\frac{1}{2}$	$7\frac{1}{2}$	9	9	9	9	9	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$	$10\frac{1}{2}$
" " double " " "	$4\frac{1}{4}$	$4\frac{1}{4}$	5	5	5	5	5	6	6	6	6	6	—	—	—	—
" " double " edge laps	$3\frac{3}{4}$	$3\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	6	6	6	6
" " single " " "	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	—	—	—	—	—	—	—	—	—	—	—
Maximum spacing of rivets from centre to centre: in butts of outside plating	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$2\frac{5}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$
in edges " "	$2\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	$3\frac{3}{8}$	4	4	4	4	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$
in frames, reversed frames, floors, keelsons, and beam angles	$4\frac{1}{2}$	$4\frac{1}{2}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$5\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	$6\frac{1}{4}$	7	7	7	7

MR. FAIRBAIRN'S RELATIVE STRENGTHS OF PLATES AND BUTT STRAPS.

Strength of plate unpunched	=	100
Strength of double riveted joint	=	70
Strength of single riveted joint	=	56
Strength of plate through line of rivet holes	=	100
Strength of double riveted joint	=	97
Strength of single riveted joint	=	56

Note.—In the above strengths of joints the total sectional area of the rivets in the butt is equal to sectional area of plate through line of rivet holes.

PITCHES OF RIVETS.

In watertight work up to 20 lbs. on the square inch the pitch should not exceed $3\frac{1}{2}$ diameters, and from $4\frac{1}{2}$ to 5 diameters in plates from $\frac{1}{4}''$ to $1''$; above this 5 to 6 diameters may be employed according to the usual sizes of rivets.

Lloyd's Rules for Iron Ships.

The rivets are to be not more than 4 diameters apart in the butts of the plating, and not more than 4 to $4\frac{1}{2}$ diameters in the edges of the plating, excepting in the keel, stem, and stern posts, where they may be 5 diameters, and in the frames to the outside plating, and in the reversed angle irons on frames, where they may be 8 diameters from centre to centre. The rivets in the flanges of gunwale angle irons to be spaced not more than $4\frac{1}{2}$ diameters, and those connecting iron decks and stringer plates to the beams 8 diameters.

(For Tables of riveting see pages 245–251.)

Admiralty Rules for Iron Ships.

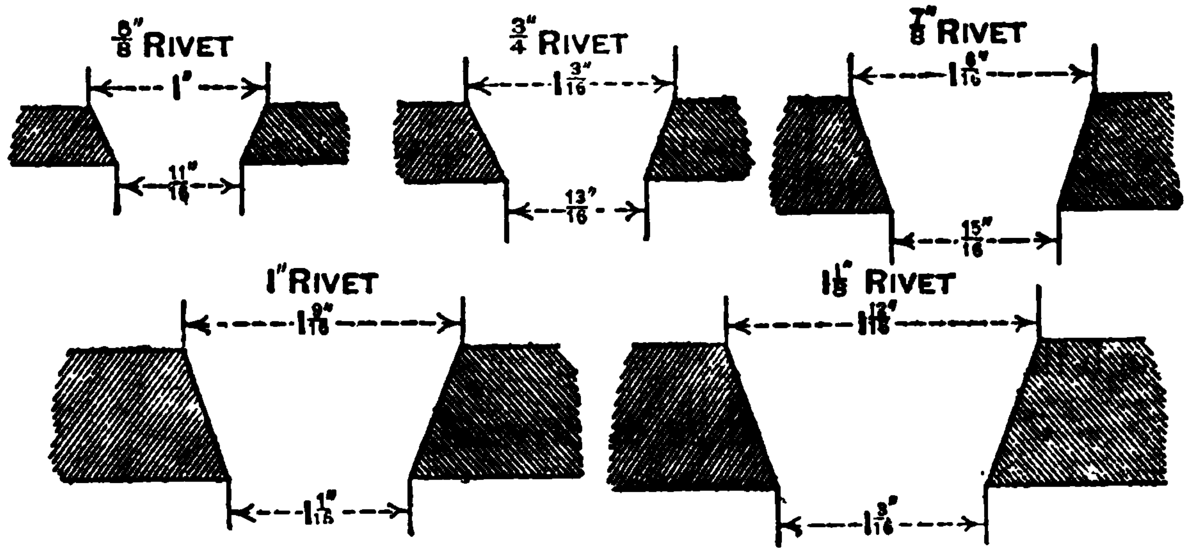
Not more than $4\frac{1}{2}$ to 5 diameters apart in edges and butts of bottom and bulkhead plating, and 5 to 6 diameters in watertight work elsewhere, and in transverse frames to outside plating about 8 diameters apart from centre to centre; in the vertical flanges to the floors, &c., about 6 diameters, and in the angle bars to non-watertight longitudinals about 7 diameters.

SIZE OF COUNTERSINK FOR RIVETS OF OUTSIDE PLATING.

In iron or steel ships, rivets to be $\frac{1}{4}''$ larger in diameter in the stem, stern frame, and keel, but in no case need these exceed $1\frac{1}{4}''$ diameter and spaced 5 diameters apart. In rudder to be of not less size than required for upper edge of garboard strake amidships, spaced not more than 5 diameters apart. Connecting flat keel plates and the fore and aft angles, spaced not more than 5 diameters apart. In butts of deck plating, spaced 4 diameters, and edges 4 to $4\frac{1}{2}$ diameters apart. In butts and edges of inner bottom plating and in butts of girders, spaced not more than

4 diameters apart. In the lands and butts of mast plates, spaced 5 diameters apart.

FIG. 207.



Lloyd's Rules for Iron and Steel Masts.

Diameter of mast at partners in inches to equal $\frac{1}{3}$ extreme length of mast in feet. Diameter at heel $\frac{7}{9}$, at hounds $\frac{5}{6}$, at head $\frac{2}{3}$ diameter at partners.

Masts from 48 to 72 feet extreme length to have two plates in the round, from 75 to 96 feet to have three plates in the round.

Diameter of bowsprit at heel in inches to equal length outside bed in feet; diameter at bed $\frac{9}{5}$, and at caps $\frac{5}{6}$ diameter at heel.

Butt Straps and Riveting by Lloyd's Rules.

In vessels whose plating number does not exceed 8,000 (see pp. 392 and 393), the butt straps of the sheerstrake, deck stringer plate, and one strake at the bilges for half the vessel's length amidships $\frac{1}{20}''$ thicker than the plates they connect, and double riveted. 8,000 to 13,000, the butt straps of the sheerstrake, deck stringer plate, and two strakes round the bilges $\frac{2}{20}''$ thicker than the plates they connect for half the vessel's length amidships, and treble riveted. 13,000 to 16,000, an additional strake of bilge plating is treble riveted at the butts for half the length amidships, with straps $\frac{2}{20}''$ thicker than the plates they connect. 16,000 to 20,000, the butts of sheerstrake, deck stringer plate, three strakes of bilge plating, and remaining outside strakes of plating treble riveted with straps $\frac{2}{20}''$ thicker than the plates they connect for half the vessel's length amidships. 20,000 to 24,000, all the butts, including those of the upper and middle deck stringer plates, treble riveted for half the vessel's length amidships, with straps $\frac{3}{20}''$ thicker than the plates, with rivets in the back row spaced 5 to $5\frac{1}{4}$ diameters apart, and the remaining butt straps $\frac{2}{20}''$ thicker than the plates. 20,000 to 28,000, the butts of the upper deck stringer plate are to have double straps for half the vessel's length amidships, or the butts may be lapped

and treble riveted; but where the plating number is 28,000 and above double butt straps are to be fitted to the stringer plates for half the vessel's length. 24,000 to 28,000, all the butt straps, including those of the upper and middle deck stringer plates, treble riveted for three-quarters the length amidships, with the back row of rivets spaced 5 to $5\frac{1}{2}$ diameters apart. The butt straps for half the length amidships $\frac{4}{20}''$ thicker than the plates, and the remaining butt straps $\frac{2}{20}''$ thicker than the plates. Above 28,000, the whole of the butt straps, all fore and aft, including those of the upper and middle deck stringer plates, treble riveted, with the back row of rivets spaced 5 to $5\frac{1}{2}$ diameters apart, and $\frac{4}{20}''$ thicker than the plates for three-quarters the length amidships, and $\frac{2}{20}''$ at the ends. In vessels of this size and exceeding 12 depths in length, double butt straps fitted to the sheerstrake and strake below.

The butt straps of flat keel plates treble riveted, and as much thicker than the plates they connect as is required for bilge strakes.

The rivets in the butt straps of outside plating, and the upper and middle deck stringer plates, spaced not more than $3\frac{1}{2}$ diameters apart from centre to centre, except in the back rows in treble riveted butt straps, which are to be spaced 5 to $5\frac{1}{2}$ diameters.

When plates forming the outside strakes of plating are above 40″ but not exceeding 46″, or those forming the inside strakes are 48″ in breadth and not exceeding 54″, their butts treble riveted with straps $\frac{1}{20}''$ thicker than the plates.

In vessels where the plating number is under 16,000, lap butts of outside plating for half the vessel's length amidships treble riveted, remaining butts double riveted; and where the plating number is 16,000 and above, lap butts treble riveted throughout. The treble riveted butts have three complete rows of rivets.

Where double butt straps are fitted to stringer plates, sheerstrakes, and outside plating, thickness of straps given in the following table:—

Thickness of Plating	Straps which are countersunk for Rivets	Strap on opposite side of Plate
Ins.	Ins.	Ins.
$\frac{9}{20}$	$\frac{7}{20}$	$\frac{6}{20}$
$\frac{10}{20}$	$\frac{8}{20}$	$\frac{6}{20}$
$\frac{11}{20}$	$\frac{8}{20}$	$\frac{7}{20}$
$\frac{12}{20}$	$\frac{9}{20}$	$\frac{7}{20}$
$\frac{13}{20}$	$\frac{10}{20}$	$\frac{8}{20}$
$\frac{14}{20}$	$\frac{10}{20}$	$\frac{8}{20}$
$\frac{15}{20}$	$\frac{11}{20}$	$\frac{9}{20}$
$\frac{16}{20}$	$\frac{12}{20}$	$\frac{10}{20}$
$\frac{17}{20}$	$\frac{12}{20}$	$\frac{11}{20}$
$\frac{18}{20}$	$\frac{13}{20}$	$\frac{11}{20}$
$\frac{19}{20}$	$\frac{14}{20}$	$\frac{12}{20}$
$\frac{20}{20}$	$\frac{14}{20}$	$\frac{12}{20}$
$\frac{21}{20}$	$\frac{15}{20}$	$\frac{13}{20}$
$\frac{22}{20}$	$\frac{15}{20}$	$\frac{14}{20}$

The landing edges of outside plating when $\frac{7}{20}''$ thickness and

above from the keel to the upper turn of bilge and the sheer-strake in all cases, and when $\frac{9}{20}''$ and above from upper turn of bilge to the gunwale, double riveted; below these thicknesses the edges single riveted. In all cases the thicker of the two plates or angles is to regulate size of rivets and requirements as to double riveting. If plating amidships the edges double riveted, to be continued right fore and aft. The stem, sternpost, keel, butts of outside plating, breasthooks, transoms, stringer and tie-plates on beams, butts of keelsons, stringers, and all longitudinal ties double riveted in all vessels.

The butts of outside plating chain riveted; also all double and treble riveting, except in the keel, stem, and sternpost.

Butts of outside plating, a space equal to twice the diameter of the rivet between each row, and also in treble riveting with half the number of rivets in the back row, in vessels whose plating number is 20,000 or under; and above, the rivets in the back row not more than 5 to $5\frac{1}{4}$ diameters from centre to centre.

Rivets not nearer to the butts or edges of the plating, butt straps, or of any angle bars than a space equal to their diameter; in edge riveting, the space between any two consecutive rows of rivets not less than $1\frac{1}{2}$ their diameter.

Rivet holes placed not more than $3\frac{1}{2}$ diameters of the rivet apart from the centre to centre in butts of outside plating, upper, spar, and middle deck stringer plates, and not more than from 4 to $4\frac{1}{2}$ diameters apart in edges of the plating and at other parts; excepting in keel, stem, sternpost, where they may be 5 diameters, and keelsons, floors, frames and reversed frames, frames and outside plating and beam angles, where they may be 7 diameters apart from centre to centre. Rivets in the flanges of the gunwale angle bars spaced not more than $4\frac{1}{2}$ diameters apart, and those connecting steel decks and stringer plates to beams spaced 7 to 8 diameters apart, butts of deck plating 4 diameters, in edges from 4 to $4\frac{1}{2}$ diameters apart.

Spacing of rivets in double angles of flat-plate keels not more than 5 diameters.

Lloyd's Rules for Freeing Port Area in Well-decked Vessels.

In well-deck vessels, the freeing port area in the 'well' should be in accordance with the following table:—

Length of Bulwarks in 'Well, in Ft.	Freeing Port Area on each Side, in Sq. Ft.
30	9·5
35	10·0
40	10·5
45	11·0
50	11·5
55	12·0
60	12·5
65 and above 1 sq. ft. to each 5 ft. length of bulwarks.	

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'DUNCAN' AND 'CORNWALLIS.'

	Description of Work	Thicknesses Riveted (in Ins.)	Breadth of Lap in Diam.	Pitch in Diam.	Head	Point	Diam. in Inches
Flat keel plates.	Inner to outer at edge amidships	$\frac{3}{4}$ $\frac{5}{8}$	—	$4\frac{1}{2}$–5	Pan	Countersunk	1
	" " forward and aft	$\frac{5}{8}$ $\frac{1}{2}$	—	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	" " butts amidships	$\frac{3}{4}$ $\frac{5}{8}$	$8\frac{1}{2}$	4–$4\frac{1}{2}$	"	"	1
	" " forward and aft	$\frac{5}{8}$ $\frac{1}{2}$	"	4–$4\frac{1}{2}$	"	"	$\frac{7}{8}$
	Outer to garboard amidships	$\frac{3}{4}$ $\frac{5}{8}$	6	$4\frac{1}{2}$–5	"	"	1
	" " forward and aft	$\frac{5}{8}$ $\frac{1}{2}$	"	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	Inner and outer to vertical keel angles	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{5}{8}$	—	$4\frac{1}{2}$–5	"	"	1
	" " " bracket frame angles	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{7}{16}$	—	7–8	"	"	$\frac{7}{8}$
	" " " watertight frame angles	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{3}{8}+$	—	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	" " " lightened plate frame angles	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{3}{8}+$	—	7–8	"	"	$\frac{7}{8}$
Vertical keel	To butt straps amidships	$\frac{5}{8}$ $\frac{3}{8}$	$8\frac{1}{2}$	4–$4\frac{1}{2}$	"	Knobbled	$\frac{7}{8}$
	" " forward and aft	$\frac{1}{2}$ $\frac{5}{16}$	"	4–$4\frac{1}{2}$	"	"	$\frac{7}{8}$
	To lower angles, 2 in No.	$\frac{1}{2}$ $\frac{3}{8}$ $\frac{5}{8}$ $\frac{5}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	To upper " "	$\frac{5}{8}$ $\frac{9}{16}$ $\frac{9}{16}$ or $\frac{1}{2}$ $\frac{3}{8}+$ $\frac{3}{8}+$	—	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	To frame " "	$\frac{3}{8}$ or $\frac{1}{2}$, $\frac{3}{8}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{7}{8}$
	To W.T. frame angles, 2 in No.	$\frac{5}{8}$ or $\frac{1}{2}$, $\frac{3}{8}+$ $\frac{3}{8}+$	—	$4\frac{1}{2}$–5	"	"	$\frac{7}{8}$
	To lightened plate frame angles, 2 in No.	"	—	7–8	"	"	$\frac{7}{8}$
Ordinary longitudinals.	To butt laps	$\frac{7}{16}$ $\frac{7}{16}$	$5\frac{3}{4}$	5	"	"	$\frac{3}{4}$
	To outer angles	$\frac{7}{16}$ $\frac{3}{8}+$	—	7–8	"	"	$\frac{3}{4}$
	To inner "	$\frac{7}{16}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{3}{4}$
	To W.T. frames	$\frac{7}{16}$ $\frac{3}{8}+$ $\frac{3}{8}+$	—	$4\frac{1}{2}$–5	"	"	$\frac{3}{4}$
	To ordinary and lightened plate frame angles	$\frac{7}{16}$ $\frac{3}{8}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{3}{4}$

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'DUNCAN' AND 'CORNWALLIS'—*continued.*

Description of Work		Thicknesses Riveted (in Ins.)	Breadth of Lap in Diam.	Pitch in Diam.	Head	Point	Diam. in Inches
Water-tight longitudinals	To butt laps	[illegible] [illegible]	5½	4–4½	Pan	Knobbled	[illegible]
	To outer angles	[illegible] [illegible]+	—	4½–5	"	"	[illegible]
	To inner angles	[illegible] [illegible]	—	4½–5	"	"	[illegible]
	To W.T. frame angles	[illegible] [illegible]+ [illegible]+	—	4½–5	"	"	[illegible]
	To ordinary and lightened plate frame angles	[illegible] [illegible] [illegible]	—	7–8	"	"	[illegible]
Longitudinals forward and aft	To bottom plating	[illegible] [illegible]	—	7–8	"	Countersunk	[illegible]
		[illegible] [illegible]		7–8	"	Knobbled	[illegible]
Bracket frame plates		[illegible] [illegible]	—	7–8	Snap	Machine snap	[illegible]
" "		[illegible] [illegible]	—	7–8	"	"	[illegible]
Watertight frames		[illegible] [illegible]	—	4½–5	"	"	[illegible]
" "		[illegible] [illegible]+	—	4½–5	"	"	[illegible]
Floors before and aba double bottom		[illegible] [illegible]+	—	7–8	Pan	Knobbled	[illegible]
		[illegible] [illegible]	—	7–8	"	"	[illegible]
Outer bottom platin (up to armour deck)		[illegible] [illegible] or [illegible] [illegible]	6	4½–5	"	Countersunk	[illegible]
		[illegible] [illegible] or [illegible] [illegible]	5½	4–4½	"	"	[illegible]
		[illegible] [illegible] or [illegible] [illegible]	—	7–8	"	"	[illegible]
		[illegible] [illegible] or [illegible] [illegible]	—	4½–5	"	"	[illegible]
		[illegible] or [illegible] [illegible]	—	7–8	"	"	[illegible]
		[illegible] or [illegible] [illegible]+	—	4½–5	"	"	[illegible]
		[illegible] or [illegible] [illegible]+	—	7–8	"	"	[illegible]
Inner bottom plating	Butts of M.L. strake in machinery spaces	[illegible] [illegible]	8¼	4–4½	"	Knobbled	[illegible]
	Edges " "	[illegible] [illegible] or [illegible]	6	4½–5	"	"	[illegible]
	Butts of plating in engine-room	[illegible] [illegible]	6	4–4½	"	"	[illegible]
	Edges " "	[illegible] [illegible]	6	4½–5	"	"	[illegible]
	Edges generally	[illegible] [illegible]	8¼	4½–5	"	"	[illegible]

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'DUNCAN' AND 'CORNWALLIS'—*continued.*

Description of Work		Thicknesses Riveted (in Ins.)	Breadth of Lap in Diam.	Pitch in Diam.	Head	Point	Diam. in Inches
Inner bottom plating	Butts "	[illegible]	6	4–4½	Pan	Knobbled	[illegible]
	To W.T frames (to M.L. strake)	[illegible]	—	4½–5	"	"	[illegible]
	To ordinary frames (to M.L. strake)	[illegible] $\frac{7}{16}$	—	7–8	"	"	[illegible]
	To [illegible]	[illegible] $\frac{7}{16}$	—	4½–5	"	"	[illegible]
	To [illegible] here	[illegible] $\frac{7}{16}$	—	7–8	"	"	[illegible]
	To [illegible]	[illegible]	—	4½–5	"	"	[illegible]
	To [illegible]	[illegible] +	—	4½–5	"	"	[illegible]
	To ordinary longitudinals	[illegible]	—	7–8	"	"	[illegible]
	To W.T. "	[illegible]	—	4½–5	"	"	[illegible]
	To lightened plate frames	[illegible]	—	7–8	"	"	[illegible]
Plating on side before and abaft citadel above protective deck	Butts	[illegible]	6	4–4½	"	Countersunk	[illegible]
	Edges	[illegible]	5½ & 3½	4½–5	"	"	[illegible]
Between main and upper decks above armour	Edges	[illegible]	3½	4½–5	"	"	[illegible]
	Butts	[illegible]	5½	4–4½	"	"	[illegible]
	To ordinary frame	[illegible]	—	7–8	"	"	[illegible]
	To W.T. bulkhead	[illegible] +	—	4½–5	"	"	[illegible]
	Lower edge to armour	[illegible]	6	4½–5	Countersunk	Screw	[illegible]
Plating between upper and boat decks	Edges	[illegible]	3½	4½–5	Pan	Countersunk	[illegible]
	Butts	[illegible]	5½	4–4½	"	"	[illegible]
	To frames, &c.	[illegible]	—	7–8	"	"	[illegible]
Covering plate to armour deck.	To bottom plating	[illegible]	—	4½–5	"	"	[illegible]
" "	To armour " "	[illegible]	3½	4½–5	Countersunk	Screw	1
Protective plating on side forward	Boundary edges to side plating	2 [illegible] [illegible]	—	6	Pan	Countersunk	1⅛
	Other " "	2 [illegible] [illegible]	—	7	"	"	$1\frac{1}{16}$
	Butts to side plating	2 [illegible] [illegible]	—	7	"	"	1⅛
Protective plating on side aft.	Edges to side plating	[illegible]	—	4½–5	"	"	⅞
" " "	Butts " "	[illegible]	—	4–4½	"	"	⅞

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'DUNCAN' AND 'CORNWALLIS'—*continued.*

Description of Work		Thicknesses Riveted (in Ins.)	Breadth of Lap in Diam.	Pitch in Diam.	Head	Point	Diam. in Inches
Principal transverse bulkheads	T-bar edge strips	$\frac{3}{8}$ $\frac{3}{8}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	Pan	Knobbled	$\frac{3}{4}$
"	Butt straps	$\frac{3}{8}$ $\frac{3}{8}$ $\frac{3}{8}$	$3\frac{1}{4}$	$4\frac{1}{2}$–5	"	"	$\frac{3}{4}$
"	Stiffeners	$\frac{3}{8}$ $\frac{3}{8}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{3}{4}$
"	Boundary angles	$\frac{3}{8}$ $\frac{7}{16}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{3}{4}$
"	12 in. I-stiffeners to plating and each other	$\frac{9}{16}$ $\frac{3}{8}$ $\frac{9}{16}$	—	7–8	"	"	$\frac{3}{4}$
Platform deck, 10 lbs.	Edges and butts	$\frac{1}{4}$ $\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
" "	To beams	$\frac{1}{4}$ $\frac{7}{16}$	—	7–8	"	"	$\frac{5}{8}$
" "	To bulkhead boundary bars	$\frac{1}{4}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
" 15 lbs.	Edges and butts	$\frac{3}{8}$ $\frac{3}{8}$	$3\frac{1}{2}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
" "	To beams	$\frac{3}{8}$ $\frac{7}{16}$	—	7–8	"	"	$\frac{5}{8}$
" "	To bulkhead boundary bars	$\frac{3}{8}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
Lower deck, within citadel, 10 lbs. plain	Edges and butts	$\frac{1}{4}$ $\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
"	To beams	$\frac{1}{4}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{5}{8}$
"	To bulkhead boundary bars	$\frac{1}{4}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
Lower deck, within citadel, 15 lbs. chequered	Edges and butts	$\frac{3}{8}$ $\frac{3}{8}$	$3\frac{1}{2}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
"	To beams	$\frac{3}{8}$ $\frac{3}{8}$	—	7–8	"	"	$\frac{5}{8}$
"	To bulkhead boundary bars	$\frac{3}{8}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
Lower-deck forward and middle deck amidships. (2 thicknesses, 20 lbs.)	Edges and butts	$\frac{1}{2}$ $\frac{1}{2}$	$3\frac{1}{4}$	6–$6\frac{1}{2}$	"	Countersunk	$\frac{3}{4}$
"	Beams	$\frac{1}{2}$ $\frac{1}{2}$	—	7–8	"	"	$\frac{3}{4}$
"	To boundary bars on bkds. above	$\frac{1}{2}$ $\frac{1}{2}$ $\frac{3}{8}$	—	5	"	Knobbled	$\frac{3}{4}$
"	" " below	$\frac{1}{2}$ $\frac{3}{8}$	—	5	"	Countersunk	$\frac{3}{4}$
Lower-deck aft. (2 thicknesses, 40 lbs.)	Longitudinal seams	1 1	$3\frac{1}{8}$	7	"	"	$1\frac{1}{8}$
"	Butts	1 1	—	6	"	"	$1\frac{1}{8}$
"	To boundary bars on bkds. above	1 $\frac{5}{8}$	—	5	Tapped	Tapped	$\frac{7}{8}$
"	" " below	1 $\frac{5}{8}$	—	5	Pan	Countersunk	$\frac{7}{8}$
"	To beams	1 $\frac{1}{2}$	—	7–8	"	"	$\frac{7}{8}$
Middle-deck forward and aft.	Edges	$\frac{3}{8}$ $\frac{3}{8}$	$3\frac{1}{2}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
" "	Butts	$\frac{3}{8}$ $\frac{3}{8}$	$5\frac{3}{4}$	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$
" "	To beams	$\frac{3}{8}$ $\frac{1}{2}$	—	7–8	"	"	$\frac{5}{8}$
" "	To blkd. boundary bars.	$\frac{3}{8}$ $\frac{3}{8}$	—	$4\frac{1}{2}$–5	"	"	$\frac{5}{8}$

TABLE OF THE SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'DUNCAN' AND 'CORNWALLIS'—*continued.*

Description of Work		Thicknesses Riveted (in Ins.)		Breadth of Lap in Diam.	Pitch in Diam.	Head	Point	Diam. in Inches
Main-deck amidships. (2 thicknesses of 40 lbs.)	Butts	1	1	—	6	"	"	1⅛
	Edges	1	1	3½	7	"	"	1⅛
	To beams	1	½	—	7–8	"	"	1
	To upper boundary bars	1	⅜	—	5–6	Tapped	Tapped	⅞
	To lower " "	1	⅜	—	5–6	Pan	Countersunk	⅞
Main-deck aft. (1 thickness, 10 lbs.)	Butts	¼	¼	5¾	4½–5	"	Countersunk or knobbled	⅝
	Edges	¼	¼	3½	4½–5	"	"	⅝
	To beams	¼	½	—	7–8	"	"	⅝
Main-deck stringer aft, 15 lbs.	Butts	⅜	⅜	5¾	4½–5	"	"	⅝
" " "	To beams	⅜	½	—	7–8	"	"	⅝
Main-deck forward. (2 thicknesses, 30 lbs.)	Butts	¾	¾	—	6	"	Countersunk	1
	Edges	¾	¾	3½	7	"	"	1
	To beams	½	¾	—	7–8	"	"	1
Main-deck forward. (2 thicknesses, 20 lbs.)	Butts	½	½	—	6–6½	"	"	⅞
	Edges	½	½	3½	6–6½	"	"	⅞
	To beams	½	½	—	7–8	"	"	⅞
Upper-deck stringer, 20 lbs.	Butts	½	½	5¾	3½–4	"	Knobbled	⅞
" " "	Edges	½	½	3½	4½–5	"	"	⅞
" " "	To beams	½	½	—	7–8	"	"	⅞
" " 15 lbs.	Butts	⅜	⅜	5¾	3½–4	"	"	¾
" " "	Edges	⅜	⅜	3½	4½–5	"	"	¾
" " "	To beams	⅜	½	—	7–8	"	"	¾
" plating, 15 lbs.	Butts	⅜	⅜	6	3½–4	"	"	¾
" " "	Edges	⅜	⅜	3½	4½–5	"	"	¾
" " "	To beams	⅜	½	—	7–8	"	"	¾
" " 10 lbs.	Butts	¼	¼	6	3½–4	"	"	⅝
" " "	Edges	¼	¼	3½	4½–5	"	"	⅝
" " "	To beams	¼	½	—	7–8	"	"	⅝

TABLE OF SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'BLENHEIM.'

Description of Work	Thickness Riveted	Breadth of Lap	Diam. of Rivets	Pitch	Remarks
	Inches	Diam.	Inches	Diam.	
Flat keel to butts amidships	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{5}{8}$	$8\frac{1}{4}$	$\frac{7}{8}$	$4-4\frac{1}{2}$	Pan heads, countersunk points
” ” fore and aft	$\frac{5}{8}$ $\frac{1}{2}$ $\frac{1}{2}$	$8\frac{1}{4}$	$\frac{7}{8}$	$4-4\frac{1}{2}$	
” to keel angles	$\frac{3}{4}$ $\frac{5}{8}$ $\frac{5}{8}$	—	1	5	
” to garboard	$\frac{3}{4}$ $\frac{9}{16}$ full	$5\frac{1}{2}$	$\frac{7}{8}$	$4-4\frac{1}{2}$	
Vertical keel to butts	$\frac{1}{2}$ $\frac{9}{16}$ full	$8\frac{1}{4}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	Pan heads, hammered points
” to lower angles	$\frac{1}{2}$ $\frac{5}{8}$ $\frac{5}{8}$	—	1	5	
” to upper angles	$\frac{1}{2}$ $\frac{7}{16}$ $\frac{7}{16}$	—	$\frac{7}{8}$	5	
” to frame angles	$\frac{1}{2}$ $\frac{3}{8}$	—	$\frac{3}{4}$	7	
” to watertight frame	$\frac{1}{2}$ $\frac{7}{16}$	—	$\frac{3}{4}$	$4\frac{1}{2}$	
Stem and sternpost to outer bottom	$\frac{1}{2}$ $\frac{5}{8}$	$5\frac{3}{4}$	$\frac{7}{8}$ lap	$4-4\frac{1}{2}$	To be $\frac{3}{4}$ ordinary rivets where practicable
Longitudinals 1st & 3rd from keel plate to outer angle	$\frac{7}{16}$ $\frac{7}{16}$	—	$\frac{3}{4}$	7–8	To be reduced to $4\frac{1}{2}$ diam. in wake of butts, so as to shorten strap. Pan heads, hammered points
” ” ” ” inner ”	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	7–8	
” ” ” ” butts	$\frac{7}{16}$ $\frac{7}{16}$	$5\frac{3}{4}$	$\frac{7}{8}$	$4\frac{1}{2}-5$	
” ” ” ” w.t. frames	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	$4\frac{1}{2}$	
” ” ” ” ordinary frames	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	7	
Longitudinals 2nd & 4th from keel w.t. plate to outer angle	$\frac{7}{16}$ $\frac{7}{16}$	—	$\frac{3}{4}$	$4\frac{1}{2}$	See note to 1st and 3rd longitudinals. Pan heads, hammered points
” ” ” ” ” inner angle	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	$4\frac{1}{2}$	
” ” ” ” ” butts	$\frac{7}{16}$ $\frac{7}{16}$	$5\frac{3}{4}$	$\frac{7}{8}$	$4\frac{1}{2}-5$	
” ” ” ” ” w.t. frame	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	$4\frac{1}{2}-5$	
” ” ” ” ” ord'y frame	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	7	
Longitudinals forward and aft, inner angle to Z frame	$\frac{7}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	8	
” ” ” to outer bottom	$\frac{7}{16}$ $\frac{1}{2}$	—	$\frac{3}{4}$	7–8	Pan heads, countersunk points
Bracket frames, bracket plates to angles	$\frac{7}{16}$ $\frac{5}{16}$	—	$\frac{3}{4}$	7–8	Pan heads, snap points, machine

TABLE OF SIZES AND PITCHES OF RIVETS AS EMPLOYED IN H.M.S. 'BLENHEIM'—*continued.*

Description of Work	Thickness Riveted	Breadth of Lap	Diam. of Rivets	Pitch	Remarks
	Inches	Diam.	Inches	Diam.	
Watertight frames, plates to angle bars	$\frac{5}{16}$ $\frac{3}{8}$	—	$\frac{3}{4}$	$4\frac{1}{2}$	Pan heads, snap points, machine
Floors before and abaft d.b. floor plates to frames	$\frac{7}{16}$ $\frac{5}{16}$	—	$\frac{3}{4}$	8	Pan heads, hammered points, machine where practicable
" " " " " reverse frames	$\frac{3}{8}$ $\frac{5}{16}$	—	$\frac{3}{4}$	8	
Outer bottom plating below l.w.l. to laps	$\frac{9}{16}$ full	$5\frac{1}{2}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	
" " " " " butts	"	$5\frac{3}{4}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	
" " " " " longitudinal angles	$\frac{7}{16}$ $\frac{9}{16}$ full	—	$\frac{3}{4}$	w.t. $4\frac{1}{2}-5$; body $7-8$	Pan heads, countersunk points
" " " " " ordinary frames	"	—	$\frac{3}{4}$	8	
" " " " " w.t. frames	"	—	$\frac{3}{4}$	$4\frac{1}{2}-5$	
Inner bottom to laps (clinker)	$\frac{3}{8}$ bare	$3\frac{1}{2}$	$\frac{5}{8}$	$4-4\frac{1}{2}$	On flat portion pan heads, countersunk points, and hammered points above where the floor rises
" butts (lapped)	"	6	$\frac{5}{8}$	$4-4\frac{1}{2}$	
" w.t. frames	$\frac{3}{8}$ $\frac{3}{8}$ bare	—	$\frac{3}{4}$	$4\frac{1}{2}-5$	
" ordinary frames	$\frac{7}{16}$ "	—	$\frac{3}{4}$	$7-8$	
" vertical keel and w.t. longitudinals	$\frac{7}{16}$ $\frac{3}{8}$ "	—	$\frac{3}{4}$	$4\frac{1}{2}$	
" non-w.t. longitudinals	$\frac{3}{8}$ "	—	$\frac{3}{4}$	$7-8$	
Protective plating, edges	$1\frac{1}{2}$ $1\frac{1}{2}$	—	$1\frac{1}{8}$	$6-6\frac{1}{2}$	Pan heads, countersunk points
" " butts	"	—	$1\frac{1}{8}$	$6-6\frac{1}{2}$	
" " boundary angles	$1\frac{1}{2}$ $\frac{9}{16}$	—	$1\frac{1}{8}$	$6-6\frac{1}{2}$	
" thick plating, 3-inch	3	—	$2\frac{1}{4}$ lap	—	—
Top side plating, l.w.l. strake, butts	$\frac{5}{8}$ $\frac{5}{8}$	$5\frac{3}{4}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	Pan heads, countersunk points
" " " " laps	$\frac{5}{8}$ $\frac{3}{8}$ $\frac{9}{16}$ full	$5\frac{1}{2}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	
Plating up to sheer strake, laps	$\frac{3}{8}$ $\frac{3}{8}$	$5\frac{1}{2}$	$\frac{3}{4}$	$4\frac{1}{2}-5$	
" " " " butts	$\frac{3}{8}$ $\frac{3}{8}$	$5\frac{3}{4}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	
Sheer strake, laps	$\frac{3}{8}$ $\frac{3}{8}$	$5\frac{1}{2}$	$\frac{3}{4}$	$4\frac{1}{2}-5$	
" " butts	$\frac{3}{8}$ $\frac{3}{8}$ $\frac{3}{8}$	$5\frac{3}{4}$	$\frac{3}{4}$	$4-4\frac{1}{2}$	
" " to upper deck angles	"	—	$\frac{3}{4}$	5	
Above upper deck, butts	$\frac{5}{16}$ $\frac{5}{16}$	$5\frac{3}{4}$	$\frac{5}{8}$	$4\frac{1}{2}$	
" " laps (if any)	$\frac{5}{16}$	$3\frac{1}{2}$	$\frac{5}{8}$	5	
Beam arm bracket plate, protective deck	$\frac{9}{16}$ $\frac{7}{16}$	—	$\frac{7}{8}$	6	Pan heads, hammered points

STRENGTH OF MATERIALS.

DEFINITIONS.

1. *Direct extensibility* or *compressibility* is the amount of direct strain produced by each pound on the square inch of direct stress.

2. *Direct pliability* includes both of the terms 'direct extensibility' and 'direct compressibility.'

3. *Elasticity* is that property of a body by which it tends to occupy a determinate bulk and figure at a given pressure and temperature.

4. *Elastic strength* is the utmost amount of stress which a body can bear without set.

5. *Factors of safety* are of three kinds—

   I. The ratio in which the breaking load exceeds the proof load.

   II. The ratio in which the breaking load exceeds the working load.

   III. The ratio in which the proof load exceeds the working load.

6. *Modulus of elasticity* is the reciprocal of the direct pliability when the stress does not exceed the proof strength.

7. *Pliability* is the inverse of stiffness, and is measured by the quantity of strain produced by a certain fixed stress.

8. *Proof strain* is the utmost strain which a body can bear without injury.

9. *Proof strength* or *proof stress* is the utmost stress which a body can bear without suffering any diminution of stiffness or strength.

10. *Proof load* is the load which produces the proof stress.

11. *Set* is the permanent strain or alteration of shape which remains in an imperfectly elastic body after a stress has been removed.

12. *Spring* or *resilience* is the quantity of work which is required to produce the proof strain, and is one-half of the product of the proof strength of the body by its proof strain.

13. *Stiffness* is measured by the intensity of the stress required to produce a certain fixed quantity of strain.

14. *Strain* is the measure of the alteration of the shape of a body, corresponding to a given stress.

15. *Strength* or *ultimate strength* is the utmost amount of stress which a body can bear without breaking.

16. *Stress* is the intensity of a load which tends to alter the

shape of a body, and it is also the equal and opposite resistance offered by the body to its load.

17. *Ultimate strain* is the utmost strain or alteration of shape which a body can bear without breaking.

18. *Working strength* is the utmost strength to which it is considered safe to subject a body during its ordinary use as part of a structure.

19. *Working load* is the load which produces the working stress.

Notes on the Strength, &c., of Materials.

(*From 'Ship-building, Theoretical and Practical.'*)

1. The tenacity of wrought iron and puddled steel is greater in the direction in which they are rolled than in the direction of their breadth, but in cast steel it is the reverse.

Table of the Conditions in which Iron is Found in its Ores.

Oxides of Iron			By Chemical Equivalents*	By Weight		Percentage of Iron
Native iron is nearly pure, or combined with one-fourth to one-hundredth part of its weight of nickel			—	—		80 to 100
Protoxide or black oxide of iron .		iron .	2	56	72	78
		oxygen	1	16		
Peroxide or red oxide of iron .		iron .	4	112	160	70
		oxygen	3	48		
Magnetic oxide of iron . . .		iron .	3	84	116	72·4
		oxygen	2	32		
Hydrate of peroxide of iron	peroxide of iron, 2 equivalents .	iron .	8	224	374	60
		oxygen	6	144		
	water, 3 equivalents .	oxygen	3			
		hydrog.	6	6		
Carbonate of iron	protoxide of iron, 1 equivalent .	iron .	2	56	116	48·3
		oxygen	1	48		
	carbonic acid, 1 equivalent .	oxygen	2			
		carbon	2	12		

2. *Brown iron ore* is hydrate of peroxide of iron nearly pure or mixed. When nearly pure and compact it is called *brown hematite*; when earthy and mixed with clay, *yellow ochre*.

3. *Carbonate of iron*, when pure and crystallised, is called *sparry iron ore*, or *spathose iron ore*; when mixed with clay and sand, *clay ironstone*. When *clay ironstone* is coloured black by carbonaceous matter it is called *black-band ironstone*.

* The chemical equivalents adopted in the above table are as follows:—oxygen, 16; carbon, 6; hydrogen, 1; iron, 28.

4. *Magnetic iron ore* consists of magnetic oxide of iron, and contains about 72 per cent. of iron.

5. *Red iron ore* is *peroxide of iron* pure or mixed. When pure and crystalline it is called *specular iron ore*, or *iron glance*; when pure or nearly so, and in kidney-shaped masses showing a fibrous structure, it is called *red hematite*; when mixed with more or less clay and sand it is called *red ironstone* and *red ochre*.

6. The strength of iron depends mainly upon the absence of impurities, such as sulphur, calcium, and magnesium, which make it brittle at high temperatures, while silicon and phosphorus make it brittle at low temperatures.

7. *Cold-blast iron* is stronger than hot-blast.

8. Annealing cast iron diminishes its tensile strength.

9. The strength of cast iron to resist crushing or cross-breaking is increased by repeated meltings, but after the twelfth melting the resistance to cross-breaking begins to diminish.

10. Good cast iron should show a good, clear skin, with regular faces and sharp angles, and when broken the surface of fracture should be of a light bluish-grey colour and close-grained texture with a uniform metallic lustre.

11. Cast iron becomes more compact and sound when cast under pressure.

12. Strength and toughness of bar iron are indicated by a fine, close, and uniform fibrous structure, free from all appearance of crystallisation, with a clear bluish-grey colour and silky lustre on a torn surface where the fibres are shown.

13. Wrought iron has its longitudinal tenacity increased by rolling.

14. The tenacity of ordinary boiler plate is not appreciably diminished at a temperature of 395° Fahrenheit, but at a dull red heat it is diminished to about three-fourths, and the tenacity of good rivet iron increases with elevation of temperature up to about 320° Fahrenheit, at which point it is one-third greater than at ordinary atmospheric temperature.

15. Wrought iron should not be used in ship-building which will not bear a tensile strain of 20 tons per square inch.

16. The tensile strain for wrought iron should not exceed $\frac{1}{3}$ or $\frac{1}{4}$ of the breaking weight.

17. Steel is made by adding carbon to malleable iron or by abstracting carbon from cast iron.

18. The hardness and toughness of steel is increased by being hardened in oil, but its strength is reduced by being hardened in water.

19. The shearing strain of steel rivets is about one-fourth less than their tensile strength.

20. Case-hardening bolts weakens them.

21. *Bessemer steel* is made by blowing jets of air into molten pig iron and stopping the process at the instant when the proper amount of carbon remains in the iron, or else the blast is continued until all the carbon is removed, and then the proper amount of carbon along with manganese and silicon is added, the usual way of adding the carbon being by running into the molten pig iron a sufficient quantity of highly carbonised cast iron. The steel thus produced is run into ingots, which are hammered and rolled like blooms of wrought iron.

22. *Blister steel* is made by embedding bars of pure wrought iron in a layer of charcoal and subjecting them to a high temperature, or by exposing the surface of the iron to a current of carburetted hydrogen gas at a high temperature.

23. *Cast steel* is made by melting bars of blister steel in a crucible along with a small quantity of carbon and some manganese, or it may be made by melting bars of pure malleable iron with manganese and the whole quantity of carbon required to make steel.

24. *Granulated steel* is made by running melted pig iron over a wheel into a cistern of water, the lumps being then taken out and embedded in pulverised hematite or in sparry iron ore, and exposed to a sufficient temperature to cause part of the oxygen of the ore to combine with and extract the carbon from the superficial layer of each of the lumps of iron, each of which is reduced to the condition of malleable iron at the surface while its heart continues in the state of cast iron. A small quantity of malleable iron is produced by the reduction of the ore. These ingredients being melted, produce steel.

25. *Puddled steel* is made by puddling pig iron and stopping the process at the instant when the proper quantity of carbon remains; the bloom is then shingled and rolled like bar iron.

26. *Shear steel* is made by breaking bars of blister steel into lengths, and making them up into bundles or fagots, and rolling them out at a welding heat, repeating the process until a near approach to uniformity of texture and composition is obtained.

27. The ultimate elongation of really good and tough specimens of iron and steel may be taken as follows:—In

Bar iron . . .	from	·15	to	·30.
Plate iron, lengthwise	„	·04	„	·17.
„ crosswise	„	·015	„	·11.
Steel bars . .	„	·05	„	·19.
„ plates . .	„	·03	„	·19.

TESTING.

In determining the tensile or compressive strength of materials, six points should be noted:—

(1) The *elastic limit*, or the point at which *set* commences after the removal of the load.

(2) The *elastic strength*, or the greatest load the material can bear, per square inch, within the elastic limit.

(3) The *elastic strain*, or the extent the material elongates or compresses in terms of the original length.*

(4) The *breaking strain*, or the greatest extent the material will elongate or compress before rupture takes place.*

(5) The *breaking strength*, or the greatest load the material can bear, per square inch, before rupture takes place.

(6) The *contraction*, or the area of section at the place of rupture in terms of the original area of section.

LLOYD'S TESTS.

Wrought Iron.—To be of good malleable quality, and to stand a tensile stress of 20 tons per square inch with, and 18 tons across, the grain, and to stand other suitable tests.

Ship Steel.—To stand a tensile stress of not less than 28, and not exceeding 32, tons per square inch, with an elongation equal to at least 16 per cent. on a length of 8 inches.

Strips heated to a low cherry red, and cooled in water of 82° Fahr., to be bent double round a curve of which the diameter is not more than three times the thickness of the strip.

Angles for frames and bulbs for beams may have a maximum tensile strength of 33 tons.

Boiler Steel.—To stand a tensile stress of not less than 26, and not more than 30, tons per square inch, with an elongation of not less than 20 per cent. in a length of 8 inches.

Strips heated to a low cherry red, and cooled in water of 82° Fahr., to be bent to a curve of which the inner radius is not greater than one and a half times the thickness of the strip.

ADMIRALTY TESTS.

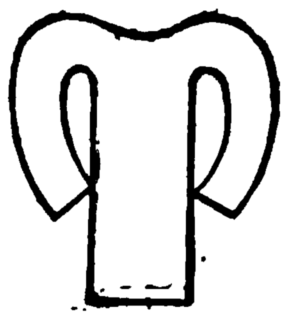
Wrought Iron.—To have a tensile strength of 22 tons to the square inch, with an elongation of 20 per cent. in a length of 8 inches.

A piece of iron, taken from each forging or bar, about 1 inch square, should admit of bending cold to a radius of $1\frac{1}{2}$ inches. A sample piece to be notched and bent cold, to ascertain the quality of the material.

Forge Tests for Bar Iron.—BB bars to be punched with a punch $\frac{1}{3}$ the diameter of the bar at distances of $1\frac{1}{2}$ and 3 dia-

* In determining the above strains for metals, it is usual to take marks $6\frac{1}{4}$ inches apart at the commencement of the experiment. The total distance between the marks at the end of the experiments, measured in 16ths of an inch, gives the strain per cent. The Admiralty and Lloyd's take the strain in a length of 8 inches.

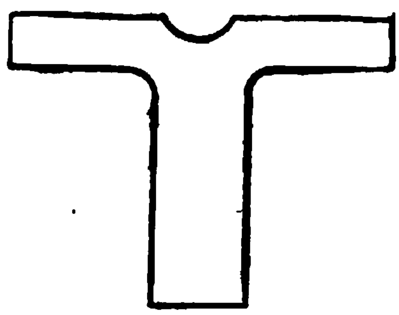
meters from the end of the bar, the holes being at right angles to one another. The holes are then to be drifted out to $1\frac{1}{4}$ times the diameter of the bar. The sides of the holes are then to be split, and the ends must admit of turning back without fracture, thus:—



Broad thick plates may be flattened on the edge to admit of being punched. A short piece of bar may be flattened down, end on, and punched as explained above.

Thin plates, $\frac{3}{4}$ inch and below, are to be bent to a radius of $2\frac{1}{2}$ times their thickness with the grain, without fracture.

B bars to be punched as in BB iron, and drifted out to one diameter of the bar. Thin flats, $\frac{3}{4}$ inch thick and below, are to be bent to a radius of 3 times their thickness with the grain, without fracture. The ends, after punching the holes, must admit of being split and turned back without fracture, thus:—



Cast Iron.—Test pieces to be taken from such castings as may be considered necessary. The minimum tensile strength to be 9 tons per square inch, taken on a length of not less than 2 inches. The transverse breaking load for a bar 1 inch square, loaded at the middle between supports 1 foot apart, is not to be less than 2,000 lbs.

Ship Steel, both Plates and Bars.—Strips cut lengthwise or crosswise, $1\frac{1}{2}$ inches wide, must stand bending double in a press, or hammering double over a block to a curve of which the inner radius is one and a half times the thickness or diameter of the steel tested. Pieces cut from rivet bars are to stand bending double in a press, or hammering double over a block to a curve of which the inner diameter is equal to the diameter of the bar tested. The strips may be tested, either cold from the plate or bar, or after having been heated uniformly to a low cherry red, and cooled in water of about 80° Fahrenheit.

The pieces of plate, beam, or angle, &c., cut out for tensile testing, are to be of parallel section for at least 8 inches of length.

They are to be cut either lengthwise or crosswise, to have an ultimate tensile stress of not less than 26, and not more than 30 tons per square inch of section, with a minimum elongation of 20 per cent. in 8 inches.

Rivet bar to have the same tensile strength, but a minimum elongation of 25 per cent. in 8 inches.

Steel Rivets.—To stand the following forge tests:—

(*a*) Bending cold without fracture in the manner shown in fig. 208 in the annexed diagram, where the line AB equals one diameter of the rivet.

(*b*) Bending hot without fracture in the manner shown in fig. 209.

(*c*) Flattening of the rivet head, when hot, in the manner shown in fig. 210 without cracking at the edges. The head to be flattened until its diameter is 2½ times the diameter of the shank.

(*d*) The shank of the rivet to be nicked on one side, and bent over to show the quality of the material.

FIG. 208.

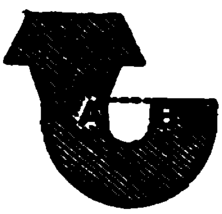
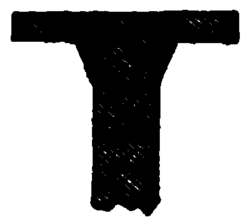


FIG. 209.

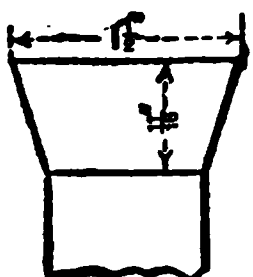
FIG. 210.



One rivet in every hundred to be forge tested as a sample.

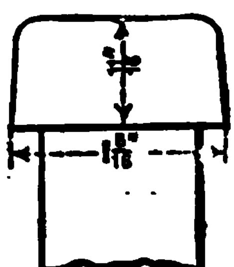
Admiralty dimensions of 1 inch rivets of the several descriptions specified in the schedule herewith.

FIG. 211.



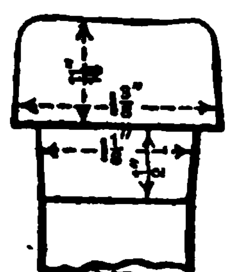
A

FIG. 212.



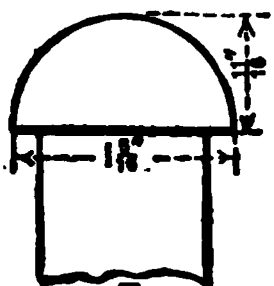
D

FIG. 213.



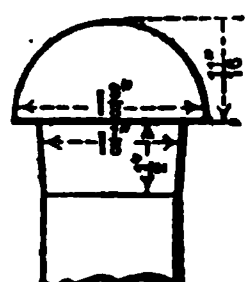
E

FIG. 214.



F

FIG. 215.



G

The lengths under heads of various descriptions of rivets for two thicknesses of plates may be determined as follows:—

Countersunk heads about 1 diameter greater than length of hole, and 1/8 inch more for three thicknesses.

Snap heads point about 1 1/4 times the diameter greater than length of hole.

Conical point about 1 1/4 to 1 1/2 times the diameter greater than length of hole.

Mild Steel for Boilers.—(i.) Plates which will not be exposed to flame and which will not be flanged, and bars, to stand a tensile stress of 27 to 30 tons per square inch, and an elongation of 20 per cent. in 8 inches. (ii.) Plates which will be exposed to flame, and plates which will be flanged, to stand a tensile stress of 24 to 27 tons per square inch and an elongation of 25 per cent. in 8 inches. Also strips cut lengthwise or crosswise, 1 1/2 inches wide, heated uniformly to a blood red and cooled in water of 82° F., must stand bending double in a press to a curve of which the inner radius is 1 1/2 times the thickness of the steel tested strips cut from the plates exposed to flame, are, in addition, to be tested by welding and forging.

SCHEDULE OF DIMENSIONS.

Diameter of Rivet	With Pan or Snap Head and Straight Necks, to Drawing D or F		With Countersunk Head, to Drawing A		With Pan or Snap Heads and Conical Necks, to Drawing E or G			
	Diameter of Head	Depth of Head	Diameter of Head	Depth of Head	Diameter of Head	Depth of Head	Diameter under Head	Depth of Cone
Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch	Inch
1 3/8	1 13/16	1	—	—	2	1	1 7/16	5/8
1 1/4	1 11/16	7/8	1 3/4	13/16	1 3/4	7/8	1 5/16	9/16
1 1/8	1 1/2	3/4	1 5/8	3/4	1 9/16	3/4	1 3/16	1/2
1	1 5/16	11/16	1 1/2	11/16	1 3/8	11/16	1 1/16	1/2
7/8	1 3/16	5/8	1 3/8	5/8	1 1/4 ‡	5/8	15/16	7/16
3/4	1 1/16	9/16	1 1/8	7/16	1 1/16	9/16	13/16	3/8
5/8	7/8	1/2	1	5/16	7/8	7/16	11/16	5/16
1/2	3/4	3/8	3/4	1/4	3/4	3/8	9/16	1/4
7/16	11/16	5/16	—	—	—	—	—	—
3/8	5/8 *	5/16 **	5/8	1/4	—	—	—	—
5/16	1/2	1/4 †	—	—	—	—	—	—
1/4	7/16	3/16	—	—	—	—	—	—
3/16	3/8	1/8	—	—	—	—	—	—

* 9/16 in. for snap heads. ** 1/4 in. for pan heads
† 3/16 in. for pan heads. ‡ 1 5/16 in. for pan heads.

Steel Rivets for Boilers.—To be made from bars, which material must stand a tensile stress of 24 to 27 tons per square inch, and have an elongation of 25 per cent. in 8 inches.

Pieces cut from bars, heated uniformly to a blood red, and cooled in water of 82° F., must stand bending double in a press to a curve of which the inner radius is equal to the radius of the bar tested.

The forge tests are the same as those for ordinary ship rivets.

Steel Forgings (Ship).—Strips cut lengthwise are to have an ultimate tensile strength of at least 28 tons per square inch of section, with an elongation of at least 27 per cent. in 2 inches. Bars, 1 inch square, should be bent cold without fracture through an angle of 180° over a radius of not more than $\frac{3}{4}$ inch.

Steel Tubes for Pillars.—To have a tensile strength of 24 to 27 tons per square inch, with an extension of at least 22 per cent. in a length of 8 inches.

The ends of the tubes are to admit of being expanded hot to an increase of $\frac{1}{20}$th of the diameter of the tube. Strips cut from the tubes, flattened, heated to a blood red, and plunged into water of 90° F., should be capable of being doubled over a radius of $\frac{1}{2}$ inch without fracture.

Steel Boiler Tubes.—(i.) Annealed pieces cut from the forging from which the tubes are to be made, are to have a tensile strength of 21 to 24 tons per square inch, and an elongation of 33 per cent. in 2 inches. (ii.) Pieces cut from the tubes, which may be annealed before testing, are to have a tensile strength of not exceeding 26 tons, and an elongation of 27 per cent. in 2 inches.

Strips cut from the tubes flattened, heated to a blood red, and cooled in water of 82° F., must be capable of being doubled over a radius of $\frac{1}{2}$ inch without fracture. The tubes themselves are to be capable of being flattened by hammering, when cold, at any part without fracture, as follows:—Tubes under $\frac{3}{16}$ inch in thickness, till the sides are close together; tubes of $\frac{3}{16}$ inch in thickness and above, till the sides are brought to a distance apart of twice the thickness of the material of the tubes.

Pieces 2 inches long, cut from the tubes, are to be capable, when cold, of being hammered down endwise until their length is reduced to 1 inch without fracture.

Admiralty Instructions for Treatment of Mild Ship Steel.

1. All plates or bars which can be bent *cold* are to be so treated; and if the whole length cannot be bent cold, heating is to be had recourse to over as little length as possible.

2. In cases where plates or bars have to be heated, the greatest care should be taken to prevent any work being done upon the material after it has fallen to the dangerous limit of temperature known as 'blue heat'—say from 600° to 400° F. Should this limit be reached during working, the plates or bars should be reheated.

3. Where plates or bars have been heated throughout for

bending, flanging, &c., and the work has been completed at one heat, subsequent annealing is unnecessary.

4. When simple forge-work has been done, such as the formation of joggles, corners, and easy curves or bends, on portions of plates or bars, and the material has not been much distressed, subsequent annealing is unnecessary.

5. Plates or bars which have had a large amount of work put upon them while hot, and have had to be reheated, should be subsequently annealed. It is preferred that this annealing should be done simultaneously over the whole of each plate or bar when this can be done conveniently. If it is inconvenient to perform the operation of annealing at one time for the whole of a plate or bar, portions may be annealed separately, proper care being taken to prevent an abrupt termination of the line of heat. If the severe working has been limited to a comparatively small part of a plate or bar, annealing may be limited to the parts which have been heated, the same care being taken to prevent an abrupt termination of the line of heat.

6. If desired, exceptionally long or quickly curved bars, such as frames, may be formed of shorter pieces with the butts suitably shifted and strapped.

7. In cases where any bar or plate shows signs of failure or fracture in working, the details of the cases should be forwarded to the Admiralty, in order that instructions may be given as to the disposal of the bar or plate.

8. It is not necessary to anneal plates or bars after punching as a means of making good damage done in punching. For plating which forms an important feature in the general structural strength, such as the outer bottom plating, deck plating, deck stringers, &c., all butt straps should have the holes drilled or be annealed after the holes are punched. In such bottom plating, the holes which are to be countersunk should be punched about $\frac{1}{8}$ inch less in diameter than the rivets which are used, the enlargement of the holes being made in the countersinking, which should in all cases be carried through the whole thickness of the plates. All countersinking to be carefully done. It is important that the whole surface of the bottom plating should be thoroughly cleared of the scale formed in manufacture before any point or composition is put upon it.

STEEL CASTINGS (SMALL).

Description of Tests to be applied.

(1) Pieces about 1 inch square, taken from each cast or 'blow' of steel, to have a minimum tensile strength of 26 tons to the square inch, with an elongation of at least 10 per cent. in a length of 8 inches.

(2) They should admit of being bent cold in a press, or on a

slab or block having a fair surface and an edge with a radius of one inch, to an angle of 45 degrees.

(3) Each casting to be lifted to a height of * feet, and allowed to fall on ground of the hardness of a good macadamised road.

(4) After the above tests have been applied, the whole of the castings to be subjected to a hammering test by the overseer to prove the soundness and efficiency of each casting, and carefully examined for any surface defects or flaws.

Steel Castings (Large).

Description of Tests to be applied.

(1) Three pieces, each about one inch square and one foot in length, to be formed on each casting for providing test pieces, or test pieces may be cut from the head of the casting.

(2) One piece to be planed, and to have a minimum tensile strength of 26 tons per square inch. The elongation to be at least 10 per cent. on a length of 8 inches.

(3) A second piece to be planed to a section one inch square, and to admit of being bent cold in a press, or on a slab or block having a fair surface and an edge with a radius of one inch, to an angle of 45 degrees.

(4) The third piece to be available for repeating either of the above tests, in case of any dispute or doubt as to the accuracy of the result.

(5) The castings to be raised $\left\{\begin{array}{l}\text{to an angle of *degrees}\\ \text{to a height of * feet}\end{array}\right\}$ and allowed to fall on ground of the hardness of a good macadamised road.

And afterwards the castings to be suspended in chains and hammered all over with a heavy sledge-hammer, and also to be carefully examined for any surface defects or flaws.

Capstan Gear Castings.

Description of Tests to be applied.

(1) Pieces about 1 inch square, taken from each cast or 'blow' of steel, should stand a minimum tensile test of 26 tons to the square inch, with an elongation of at least ten per cent. in a length of 8 inches.

(2) They should admit of being bent cold in a press, or on a block having a fair surface and an edge with a radius of 1 inch, to an angle of 45°.

(3) The body drum head, deck plate, cable-holders, &c., should admit of being dropped heavily from a height of 12 feet upon hard ground without showing any signs of fracture.

* Depending on character of casting.

(4) After the above tests have been applied, the whole of the castings to be subjected to a hammering-test to prove the soundness and efficiency of each casting, and carefully examined for any surface defects or flaws.

ON THE STRENGTH OF MILD STEEL PLATES AND RIVETS USED IN SHIPBUILDING. (J. G. WILDISH, M.I.N.A.)

(From *Transactions of the Institution of Naval Architects*, 1885.)

From experiments made with Landore steel plates and iron rivets it was found that the shearing stress of a ¾ in. rivet was only 8·1 tons, and that of a ⅞ in. rivet 11½ tons.

With steel rivets in steel plates the single shear gave 11¾ tons for a ¾ in. rivet and 14¾ tons for a ⅞ in. rivet, the double shear being 16·1 tons for a ⅝ in. rivet and 21·2 tons for a ¾ in. rivet.

The strength of a mild steel plate, when unpunched, was 28¼ tons per square inch. With holes punched in the plate the strength of the remaining material was 22 tons per square inch, showing a depreciation of 22 per cent. below the unpunched plate.

With holes drilled through the plate the breaking strength of the remaining material was 29½ tons, being greater than for the unpunched plates.

With holes punched to ¾ in. and countersunk to ⅞ in. minimum diameter, the breaking stress was 29 tons.

When the plates were riveted together by means of a single butt strap, the punched and countersunk plates gave a mean breaking stress across the holes of 28·9 tons per square inch, showing that the material had not been injured by the method of making the holes.

In the plates with the holes punched the full size required for snap rivets the mean breaking stress per square inch was 24·9 tons, being only 12 to 13 per cent. weaker than the unpunched plate; so that the process of riveting appears to have strengthened the plates.

The frictional resistance of riveted joints was as follows:—

	1 in. Rivets	¾ in. Rivets
With snap head and point . .	6·4 tons	4·72 tons
With pan head and boiler point .	7·36 „	4·52 „
With pan head and countersunk point	8·55 „	6·25 „
With countersunk head and point .	9·04 „	4·95 „

All hand riveted.

The machine rivets had snap heads and points when finished, and the mean friction per rivet was 9·6 tons for 1 in. rivets and 5·9 tons for ¾ in rivets.

MEAN RESULTS OF EXPERIMENTS WITH DIFFERENT KINDS OF RIVETS IN STEEL PLATES CONNECTED BY SINGLE BUTT STRAPS DOUBLE RIVETED.

Material of Rivet	Description of Riveting	¾ in. Rivets in ⅝ in. Plates			⅞ in. Rivets in ¾ in. Plates			1 in. Rivets in ⅞ in. Plates		
		Net Sectional Area of Rivet when finished	Mean Shearing Stress per Rivet	Mean Shearing Stress per Sq. In. of Sectional Area	Net Sectional Area of Rivet when finished	Mean Shearing Stress per Rivet	Mean Shearing Stress per Sq. In. of Sectional Area	Net Sectional Area of Rivet when finished	Mean Shearing Stress per Rivet	Mean Shearing Stress per Sq. In. of Sectional Area
		In.	Tons	Tons	In.	Tons	Tons	In.	Tons	Tons
Iron		·303	5·677	18·60	·407	7·594	18·70	·567	10·072	17·76
"		·303	6·179	20·47	·407	7·398	19·40	·567	9·868	17·41
"		·302	6·570	21·76	·407	9·312	22·88	·567	12·387	21·85
Steel		·302	6·354	21·04	·407	8·258	20·29	·567	12·388	21·88
"		·302	6·570	21·76	·407	8·571	21·05	·567	11·662	20·56
"		·302	7·318	24·24	·407	9·765	23·94	·567	14·331	25·27
"		·519	11·188	21·56	·690	15·541	22·52	·887	21·067	23·75
"		·519	12·024	23·17	·690	15·267	22·13	·887	20·000	22·55
"		·519	—	—	—	—	—	·887	[illegible]	[illegible]
"		·519	10·937	21·07	·690	14·670	21·26	·887	19·140	21·58

Strength of Iron Rivets.

From experiments made at Chatham it was found that the shearing stress of a ¾ in. rivet was 10 tons for a single shear and 18 tons for a double shear.

Admiralty Tests and Weights of Stud-linked Chain Cable.							
Diam. of Cable	Breaking Strain	Proof Strain	Weight of 100 Fathoms	Diam. of Cable	Breaking Strain	Proof Strain	Weight of 100 Fathoms
Inches	Tons	Tons	Cwts.	Inches	Tons	Tons	Cwts.
3½	264·6	176·4	588·0	1½	60·75	40·5	108·0
3¼	241·7	161·125	507·0	1⅜	51·0	34·0	90·75
3	218·7	145·8	432·0	1¼	42·19	28·125	75·0
2¾	194·0	129·3	363·0	1⅛	34·12	22·75	63·75
$2\frac{9}{16}$	177·3	118·2	315·0	1	27·0	18·0	52·75
2½	168·8	112·5	300·0	⅞	20·62	13·75	40·5
2⅜	152·2	101·5	270·75	¾	15·19	10·125	29·5
2¼	136·69	91·125	243	$\frac{11}{16}$	12·75	8·5	25·0
2⅛	121·88	81·25	216·75	⅝	10·5	7·0	20·625
2	108·0	72·0	192	$\frac{9}{16}$	8·25	5·5	16·75
1⅞	94·88	63·25	168·75	½	6·75	4·5	13·25
1¾	82·69	55·125	147·0	$\frac{7}{16}$	5·25	3·5	10·25
1⅝	71·25	47·5	126·75	⅜	3·8	2·53	7·32

Note.—The above breaking strains are 50 per cent. above the proof strain, and the proof strains are equivalent to the following strains per circular inch of iron: viz., 3¼-inch, 535·5 lbs.; 3-inch, 567 lbs.; 2¾-inch, 598·5 lbs.; $2\frac{9}{16}$-inch and under, 630 lbs. The proof strain for any cable under 2¾-inch is (diameter)^2 × 18.

Admiralty Tests and Weights of Rigging Chain and Cat Chain.								
Diam. of Chain	Breaking Strain	Proof Strain	Weight per Fathom	Diam. of Chain	Breaking Strain	Proof Strain	Weight per Fathom	
							Rigging Chain	Cat Chain
Inches	Tons	Tons	Lbs.	Inches	Tons	Tons	Lbs.	Lbs.
⅛	·43	·19	2·0	$\frac{11}{16}$	12·65	5·625	30·0	—
$\frac{3}{16}$	·92	·41	3·0	¾	15·19	6·75	36·0	35·75
¼	1·69	·75	4·75	$\frac{13}{16}$	17·72	7·875	39·0	—
$\frac{5}{16}$	2·53	1·125	6·75	⅞	20·53	9·125	48·0	49·5
⅜	3·66	1·625	9·5	$\frac{15}{16}$	23·625	10·5	53·0	—
$\frac{7}{16}$	5·06	2·25	13·25	1	27·00	12·00	61·0	64·5
½	6·75	3·00	17·0	1⅛	34·31	15·25	73·0	79·75
$\frac{9}{16}$	8·44	3·75	21·0	1¼	42·19	18·75	92·0	96·0
⅝	10·41	4·625	25·0	1⅜	50·91	22·625	108·0	116·0

Note.—The above breaking strains are two and a quarter times the proof strain. The working strain for cranes, &c., should not exceed two-ninths the breaking strain or one-half the proof strain.

Steel Wire Rope for Standing Rigging.

Size in Inches	Length of Coil	Wires in a Strand	Weight per Fathom	Standard for Breaking or Receiving Strain to be not less	Strands in a Rope
	Fms.	No.	Lbs.	Tons	No.
8	100	19	62	160	6
7½	100	19	53	141	6
7	100	19	46	123	6
6½	100	19	40	106	6
6	100	19	34	90	6
5½	100	19	28	76	6
5	100	19	23	63	6
4½	150	19	19	51	6
4	150	19	15½	40	6
3¾	150	7	11⅝	32	6
3½	150	7	10	27	6
3	200	7	8	24	6
2¾	200	7	7	19	6
2½	200	7	6	16	6
2¼	200	7	5	13	6
2	200	7	4	10	6
1¾	200	7	3	8	6
1½	200	7	2	6	6
1¼	200	7	1½	3⅜	6
1	200	7	1	2½	6

Remarks

Test A to have the undermentioned turns taken in itself in a length of 8 inches:

Size of Rope	No. of Turns	Size of Rope	No. of Turns	Size of Rope	No. of Turns	Size of Rope	No. of Turns
Ins.		Ins.		Ins.		Ins.	
8	5	5½	11	3¼	13	2	20
7½	6	5	13	3	14	1¾	22
7	7	4½	14	2¾	15	1½	26
6½	9	4	16	2½	17	1¼	28
6	10	3½	11	2¼	18	1	33

Test B to have 3 turns taken round its own part and back again.

The ductility tests will be strictly carried out, with the following modifications: viz. If, in trying seven wires, one should fail, but the other six wires give fair and uniform results, the average being up to the standard, the rope made from such wires will be considered satisfactory.

Note.—The rope supplied is to be made from the best crucible steel, and galvanised with pure zinc.

Leather Belting.

V = velocity of belt in feet per minute.
HP = horse-power (actual) transmitted by belt.
S = strain on belting in lbs.
W = width of single belting ($\frac{3}{16}$ thick) in inches.

$S = x + kx$. $\quad W = \cdot02S$. $\quad x = \dfrac{33000\,HP}{V}$.

$k = 1{\cdot}1$ when portion of driven pulley embraced by belt $= \cdot40$ circumference.
$k = \cdot77$ when portion of driven pulley embraced by belt $= \cdot50$ circumference.
$k = \cdot62$ when portion of driven pulley embraced by belt $= \cdot60$ circumference.

For double belting the width $= W \times 0{\cdot}6$.

Approximate rule for single belting $\frac{3}{16}$ thick.

$$W = \frac{1100\,HP}{V}.$$

FLEXIBLE STEEL WIRE ROPE.

Size of Rope	Length of Coil	Wires in a Strand	Strands in a Rope	Weight per Fathom	Standard for Breaking or Receiving Strain to be not less
Ins.	Fms.	No.	No.	Lbs.	Tons
8	150	30	6	53	148
7	150	30	6	41	113
6½	150	30	6	35	98
6	150	30	6	31	84
5½	150	24	6	28	71
5	150	24	6	23	59
4½	150	12	6	15	39
4	240	12	6	12	31
3½	360	12	6	9	24
3	360	12	6	7	17
2¾	360	12	6	5½	14½
2½	360	12	6	4½	11¾
2¼	300	12	6	3½	9
2	300	12	6	2¾	7
1¾	300	12	6	2	5½
1½	300	12	6	1¾	4
1¼	300	12	6	1¼	2¾
1	300	12	6	¾	1¾

Remarks

Test A to have the undermentioned turns taken in itself in a length of 8 inches:

Size of Rope	No. of Turns	Size of Rope	No. of Turns	Size of Rope	No. of Turns	Size of Rope	No. of Turns
Ins.		Ins.		Ins.		Ins.	
8	9	5	17	3	22	1¾	36
7	11	4½	15	2¾	25	1½	41
6½	14	4	17	2½	26	1¼	47
6	15	3½	18	2¼	28	1	60
5½	16			2	33		

Test B to have 8 turns taken round its own part and back again.

If, in being tested, one wire in seven fail, but the other six give fair and uniform results, the average being up to the standard, the rope will be considered satisfactory. A latitude not exceeding 5 per cent. over or under the prescribed weights will be allowed.

TORSIONAL MOMENT OF RESISTANCE FOR SHAFTS.

Calculated from the formula $M = \frac{\pi}{16} f d^3$.

M = moment of resistance to torsion. $\pi = 3{\cdot}14159$.
f = stress per square inch. d = diameter of shaft in inches.

Diameter	$f = 8,000$ lbs.	$f = 10,000$ lbs.	Diameter	$f = 8,000$ lbs.	$f = 10,000$ lbs.	Diameter	$f = 8,000$ lbs.	$f = 10,000$ lbs.
Ins.			Ins.			Ins.		
1	1,570	1,962	5¼	227,184	283,980	10½	1,817,471	2,271,839
1¼	3,066	3,832	5½	261,209	326,511	11	2,089,670	2,612,088
1½	5,299	6,624	5¾	298,472	373,090	11½	2,387,774	2,984,717
1¾	8,414	10,517	6	339,120	423,900	12	2,712,960	3,391,200
2	12,560	15,700	6¼	383,300	479,125	13	3,449,290	4,311,612
2¼	17,883	22,354	6½	431,161	538,951	14	4,308,080	5,385,100
2½	24,531	30,664	6¾	482,848	603,560	15	5,298,750	6,623,438
2¾	32,651	40,814	7	538,510	673,138	16	6,430,720	8,038,400
3	42,390	52,988	7¼	598,298	747,866	17	7,713,410	9,641,762
3¼	53,895	67,369	7½	662,344	827,930	18	9,156,240	11,445,300
3½	67,314	84,143	7¾	730,810	913,512	19	10,768,630	13,460,788
3¾	82,793	103,491	8	803,840	1,004,800	20	12,560,000	15,700,000
4	100,480	125,600	8½	964,176	1,205,220	21	14,539,770	18,174,710
4¼	120,522	150,652	9	1,144,530	1,430,662	22	16,717,360	20,896,700
4½	143,066	178,833	9½	1,346,079	1,682,599	23	19,102,190	23,877,738
4¾	168,260	210,325	10	1,570,000	1,962,500	24	21,703,680	27,129,600
5	196,250	245,313						

BULLIVANTS' GALVANISED FLEXIBLE STEEL WIRE HAWSERS AND CABLES COMPARED WITH HEMP AND CHAIN.

Flexible Steel Wire Hawsers and Cables				Chain Cable				Tarred Hemp Rope		
Size—Circumference	Weight per Fathom	Guaranteed Breaking Strain	Diam. of Barrel or Sheave round which it may be worked	Size	Weight per Fathom	Proof Strain	Breaking Strain	Size	Weight per Fathom	Breaking Strain
In.	Lbs.	Tons	In.	In.	Lbs.	Tons	Tons	In.	Lbs.	Tons
12	115	320	72	—	—	—	—	—	—	—
11	97	270	66	—	—	—	—	—	—	—
10	80	220	60	—	—	—	—	—	—	—
9	65	180	54	—	—	—	—	—	—	—
8	53	150	48	$2\frac{5}{16}$	280	$96\frac{1}{4}$	$134\frac{3}{4}$	25	146	125
$7\frac{1}{2}$	47	130	45	$2\frac{3}{16}$	256	$86\frac{1}{8}$	$120\frac{1}{2}$	24	134	115
7	41	116	42	$2\frac{1}{16}$	231	$76\frac{1}{2}$	$107\frac{1}{10}$	23	123	106
$6\frac{1}{2}$	37	102	39	$1\frac{15}{16}$	204	$67\frac{1}{2}$	$94\frac{1}{2}$	21	106	89
6	33	88	36	$1\frac{3}{4}$	166	$55\frac{1}{8}$	$77\frac{1}{8}$	19	84	72
$5\frac{1}{2}$	28	74	33	$1\frac{5}{8}$	143	$47\frac{1}{2}$	$66\frac{1}{2}$	17	67	60
5	$23\frac{1}{2}$	64	30	$1\frac{7}{16}$	112	$37\frac{1}{8}$	$55\frac{1}{2}$	15	56	50
$4\frac{1}{2}$	15	39	27	$1\frac{1}{8}$	68	$22\frac{3}{4}$	$34\frac{1}{8}$	13	39	34
4	12	33	24	1	54	18	27	12	33	29
$3\frac{1}{2}$	9	26	21	$\frac{15}{16}$	48	$15\frac{8}{10}$	$23\frac{7}{10}$	11	28	$24\frac{1}{2}$
$3\frac{1}{4}$	8	22	$19\frac{1}{2}$	$\frac{13}{16}$	35	$11\frac{7}{8}$	$17\frac{8}{10}$	10	23	20
3	7	18	18	$\frac{12}{16}$	30	$10\frac{1}{8}$	$15\frac{1}{8}$	9	19	$16\frac{1}{2}$
$2\frac{3}{4}$	$5\frac{1}{2}$	15	$16\frac{1}{2}$	$\frac{11}{16}$	25	$8\frac{1}{2}$	$12\frac{3}{4}$	$8\frac{1}{4}$	16	14
$2\frac{1}{2}$	$4\frac{1}{2}$	12	15	—	—	—	—	$7\frac{1}{2}$	13	$11\frac{1}{2}$
$2\frac{1}{4}$	$3\frac{3}{4}$	9	$13\frac{1}{2}$	$\frac{10}{16}$	21	7	$9\frac{1}{2}$	$6\frac{1}{2}$	$11\frac{1}{4}$	10
2	$2\frac{3}{4}$	7	12	—	—	—	—	$5\frac{3}{4}$	9	8
$1\frac{3}{4}$	2	$5\frac{1}{2}$	$10\frac{1}{2}$	$\frac{9}{16}$	17	$5\frac{1}{2}$	$7\frac{1}{4}$	5	$6\frac{1}{2}$	6
$1\frac{1}{2}$	$1\frac{3}{4}$	4	9	—	—	—	—	4	4	4
$1\frac{1}{4}$	1	$2\frac{1}{2}$	$7\frac{1}{2}$	$\frac{1}{2}$	14	$4\frac{1}{2}$	6	$3\frac{1}{2}$	$3\frac{1}{4}$	$2\frac{3}{4}$
1	$\frac{3}{4}$	$1\frac{3}{4}$	6	—	—	—	—	$2\frac{3}{4}$	2	$1\frac{3}{4}$

In all cases the diameter of both barrels and sheaves should be as large as practicable.

Messrs. Bullivant & Co. are prepared to make steel ropes to take a breaking strain of 1,200 tons on the single part, and they will be happy to furnish any information on application connected with larger size cables than those mentioned in above table.

BULLIVANTS' STEEL WIRE ROPES (BLACK).

Flexible Steel Wire Rope, 6 Strands, each 12 Wires				Extra Flexible Steel Wire Rope, 6 Strands, each 24 Wires		Special Extra Flexible Steel Wire Rope			
						6 Strands, each 37 Wires		Bullivants' Special Make	
Circumference	Weight per Fathom (Approx.)	Guaranteed Breaking Strain	Diameter of Barrel or Sheave round which it may be at a slow speed worked	Weight per Fathom (Approx.)	Guaranteed Breaking Strain	Weight per Fathom (Approx.)	Guaranteed Breaking Strain	Guaranteed Breaking Strain	Circumference
In.	Lbs.	Tons	In.	Lbs.	Tons	Lbs.	Tons	Tons	In.
1	·63	1·75	6	·88	2·95	1·0	—	—	1
1¼	1·06	2·5	7½	1·31	4·45	1·56	—	—	1¼
1½	1·44	4·0	9	1·88	6·7	2·00	7·25	—	1½
1¾	2·00	5·5	10½	2·5	8·75	2·88	10·0	—	1¾
2	2·44	7·0	12	3·5	11·85	4·0	13·0	—	2
2¼	3·37	9·0	13½	4·5	14·6	4·88	15·75	—	2¼
2½	4·19	12·0	15	5·44	18·55	5·88	19·75	—	2½
2¾	5·25	15·0	16½	6·25	21·95	7·0	24·0	—	2¾
3	6·25	18·0	18	7·63	25·7	8·25	29·0	—	3
3¼	7·06	22·0	19½	9·37	30·8	10·38	33·5	—	3¼
3½	8·25	26·0	21	10·75	35·2	11·5	38·5	—	3½
3¾	9·87	29·0	22½	12·19	41·1	13·38	44·5	—	3¾
4	11·25	33·0	24	13·62	46·3	15·25	51·0	—	4
4¼	12·35	36·0	25½	15·69	52·9	17·12	58·0	—	4¼
4½	13·44	39·0	27	17·75	58·6	19·0	63·5	—	4½
4¾	—	—	—	19·88	66·4	21·69	71·25	—	4¾
5	—	—	—	22·5	74·2	24·38	79·25	—	5
5¼	—	—	—	23·25	82·88	27·69	87·75	—	5¼
5½	—	—	—	24·5	91·55	31·0	96·75	—	5½
5¾	—	—	—	—	—	33·75	103·75	—	5¾
6	—	—	—	—	—	36·5	113·75	—	6
6½	—	—	—	—	—	42·5	132·0	—	6½
7	—	—	—	—	—	48·5	154·0	—	7
7½	—	—	—	—	—	55·0	178·5	—	7½
8	—	—	—	—	—	63·0	198·0	202	8
9	—	—	—	—	—	79·0	250·0	257	9
10	—	—	—	—	—	98·0	305·0	318	10
11	—	—	—	—	—	120·0	—	381	11
12	—	—	—	—	—	142·0	—	455	12

Note.—In these flexible rope tables the wire is calculated as taking a breaking strain of 90 tons to the square inch; ropes made of wire which is calculated above that will take a proportionately higher strain.

HEMP ROPE GEARING.

Ropes $5\frac{1}{4}$ to $6\frac{1}{2}$ circumference; $4\frac{1}{4}$ for small power.

Velocity of rope from 3,000 to 6,000 feet per minute.

Circumference of pulley not less than 30 times the circumference of the rope. A good proportion for the diameter of the driving pulley first motion is 100 times the diameter of the rope, second motion 50 times.

The distance of the two pulleys apart, from 30 to 60 feet.

The ropes should not rest on the bottom of the groove, which should be V-shaped, the sides being at an angle of 40°.

The length of the splice should be about 15 times the circumference of the rope.

The rope should never be strained so as to draw it to a near approach to straight, even in short spans.

Weight of ropes in lbs. per foot = ·04 c^2.

Working tension of the rope, from 110 to 120 lbs. per square inch of its section.

IRON SCREW BOLTS.—EXTREME WEIGHT THAT BOLTS WILL SAFELY CARRY. (Whitworth's Angular Threads.)

Diam. of Bolt	Diam. at Bottom of Thread	Area at Bottom of Thread	Working Load	Diam. of Bolt	Diam. at Bottom of Thread	Area at Bottom of Thread	Working Load
Inches	Inches	Inches	Tons	Inches	Inches	Inches	Tons
$\frac{3}{8}$	·295	·0683	·15	$1\frac{5}{8}$	1·369	1·4720	3·273
$\frac{7}{16}$	·346	·0940	·20	$1\frac{3}{4}$	1·494	1·7530	3·913
$\frac{1}{2}$	·393	·1213	·26	$1\frac{7}{8}$	1·590	1·9855	4·425
$\frac{5}{8}$	·509	·2034	·463	2	1·715	2·3100	5·150
$\frac{3}{4}$	·622	·3038	·675	$2\frac{1}{4}$	1·930	2·9255	6·525
$\frac{7}{8}$	·733	·4219	·937	$2\frac{1}{2}$	2·180	3·7325	8·325
1	·840	·5541	1·225	$2\frac{3}{4}$	2·384	4·4637	9·963
$1\frac{1}{8}$	·942	·6969	1·550	3	2·634	5·4490	12·600
$1\frac{1}{4}$	1·067	·8941	1·950	$3\frac{1}{4}$	2·856	6·4043	14·288
$1\frac{3}{8}$	1·162	1·0604	2·363	$3\frac{1}{2}$	3·106	7·5769	16·913
$1\frac{1}{2}$	1·287	1·3009	2·900				

Note.—The foregoing table has been run out on a factor of safety of 6, the tensile strength of material taken at 15 tons only, it having been proved experimentally that screwing small bolts reduces their strength nearly 25 per cent., thus giving 20 tons per square inch for the plain bar.

Admiralty Proof Tests for Eye-bolts, Rings, and Ring-bolts.

Diam.	Eye-bolts	Rings and Ring-bolts	Diam.	Eye-bolts	Rings and Ring-bolts
Inches	Tons	Tons	Inches	Tons	Tons
$3\frac{1}{8}$	$97\frac{21}{32}$	$39\frac{2}{32}$	$1\frac{5}{8}$	$26\frac{13}{32}$	$10\frac{18}{32}$
3	90	36	$1\frac{1}{2}$	$22\frac{16}{32}$	9
$2\frac{7}{8}$		$33\frac{2}{32}$	$1\frac{3}{8}$	$18\frac{29}{32}$	$7\frac{18}{32}$
$2\frac{3}{4}$		$30\frac{8}{32}$	$1\frac{1}{4}$	$15\frac{20}{32}$	$6\frac{8}{32}$
$2\frac{5}{8}$		$27\frac{18}{32}$	$1\frac{1}{8}$	$12\frac{21}{32}$	$5\frac{2}{32}$
$2\frac{1}{2}$		25	1	10	4
$2\frac{3}{8}$		$22\frac{18}{32}$	$\frac{7}{8}$	$7\frac{21}{32}$	$3\frac{2}{32}$
$2\frac{1}{4}$		$20\frac{8}{32}$	$\frac{3}{4}$	$5\frac{20}{32}$	$2\frac{8}{32}$
$2\frac{1}{8}$		$18\frac{2}{32}$	$\frac{11}{16}$	$4\frac{23}{32}$	$1\frac{28}{32}$
2		16	$\frac{5}{8}$	$3\frac{29}{32}$	$1\frac{18}{32}$
$1\frac{7}{8}$	$35\frac{5}{32}$	$14\frac{2}{32}$	$\frac{1}{2}$	$2\frac{16}{32}$	1
$1\frac{3}{4}$	$30\frac{20}{32}$	$12\frac{8}{32}$	$\frac{3}{8}$	$1\frac{13}{32}$	$\frac{18}{32}$

To find the proof strain for eye-bolts in tons.

Square the diameter in inches, and multiply by 10; the result will be in tons.

To find the proof strain for ring-bolts and rings.

Square the diameter in inches, and multiply by 4; the result will be in tons.

To find the proof strain for straight shackles in tons.

Square the diameter in inches, and multiply by 6; the result will be in tons.

To find the proof strain for bowed shackles in tons.

Square the diameter in inches, and multiply by 5; the result will be in tons.

Notes on Pig Iron.

No. 1. *Dark grey* fracture, large crystals and high metallic lustre, is easily fused and runs very thin when molten; principally used for fine castings requiring a sharp outline and not great strength, being soft when cast.

No. 2. Not generally used for ordinary castings, comes midway between No. 1 and No. 3.

No. 3. *Medium grey* fracture and less lustre than No. 1 or No. 2, is the most generally used for large castings; some of No. 1 is often added for complicated castings, and some of No 4 if greater hardness is required.

No. 4. *Light grey* fracture, small crystals and little lustre; used principally in the manufacture of wrought iron or with No. 3.

Nos. 5 and 6. *Mottled* or grey forge iron; not used for foundry purposes, but principally in the manufacture of wrought iron.

No. 7. Crystalline, very hard silvery white fracture, is the hardest and most brittle of all; used in the manufacture of inferior wrought iron.

CAST IRON.

Grey Cast Iron contains about 1 per cent. of carbon chemically combined with the iron, and from 1 to 4 per cent. in the form of plumbago in mechanical mixture. They are produced by a high temperature and plenty of fuel.

White Cast Iron has all its carbon chemically combined with the iron. It is produced by a low temperature and a deficiency of fuel.

Cast Iron contains from 2 to 5 per cent of carbon, is stronger under compression than wrought iron, weaker under tension. Its strength is improved by repeated meltings up to ten or twelve, but annealing diminishes its strength. Good iron should show a clean skin with regular faces and sharp angles; when broken, the fracture should be of a light bluish grey of a close-grained texture with a uniform metallic lustre.

When cast under pressure it becomes more compact and sound.

Cold Blast is stronger than *Hot Blast.*

Admiralty Engineers' Tests for Strength of Cast Iron.

The minimum tensile strength to be 9 tons per square inch, taken on a length of not less than 2 inches.

WROUGHT IRON.

Is nearly pure iron, produced by abstracting the greater portion of the carbon from cast iron, that containing about $\frac{1}{4}$ per cent. being almost equal to mild steel.

The commoner kinds are made into bars and plates. Difficult forgings, rivets, &c., are made from the better kinds, such as Lowmoor, Bowling, Farnley, &c.

The longitudinal strength is increased by rolling, and the tensile is greater with the grain than across.

Strength and toughness are indicated by a fine close-grain uniform fibrous structure, free from all appearance of crystallization, with a clear bluish grey colour and silky lustre on a torn surface; its tenacity is not appreciably diminished at a temperature of 395° Fahrenheit, but at a dull red heat it is reduced to about three-fourths.

The tenacity of good rivet iron increases with elevation of temperature up to 320° Fahrenheit. When heated and allowed to cool slowly it is softened and the breaking strain reduced, but if heated and cooled suddenly it is hardened.

Sudden fracture produces crystalline appearance, but if slowly a fibrous.

The more steely irons are more difficult to weld.

STEEL.

A compound of iron with from ·1 to 1·5 per cent. of carbon; these kinds containing less carbon are more easily welded and forged, and are termed mild steel, used for plates and forgings. The presence of manganese increases the toughness and makes it easier to weld.

Bessemer steel is produced by removing the carbon by a strong blast from molten cast iron, leaving mainly pure iron, into which a certain amount of carbon and manganese is introduced by adding speigeleisen.

The metal is then run into large ingots, and hammered and rolled like wrought iron.

Siemen-Martin's steel is the process usually preferred for making mild steel. Cast iron ores mixed in certain proportions are heated in a reverberatory furnace heated by gas, run into large ingots, and then treated the same as wrought iron.

Admiralty Tests for Ships' Plates.—Not less than 26 tons and not exceeding 30 tons per square inch tensile stress, with 20 per cent. elongation in 8 inches.

Boiler Plates.—Strips cut lengthwise or crosswise to have an ultimate strength per square inch as follows:—(1) Plates, &c., not exposed to flame, not less than 27 tons and not more than 30 tons per square inch. (2) Furnace and other plates exposed to flame, 24 to 27 tons, with a minimum elongation in the first case of 20 per cent., and in the second case of 25 per cent., taken on a length of 8 inches.

Steel castings have a very high tensile strength, but unless great care is taken in annealing they will be very brittle, otherwise they are superior to wrought or cast iron.

The hardness and toughness of steel is increased by being hardened in oil, but its strength is reduced by hardening in water.

When fractured slowly it presents a silky fibrous appearance, but if suddenly a granular appearance, nearly free of lustre and unlike the brilliant crystalline appearance of iron.

The most highly converted steel does not possess the greatest density.

COPPER.

Very tough and elastic, of considerable strength, malleable and ductile, suitable for hammering into forms requiring strength and elasticity combined with lightness, but does not make good castings.

It is hardened by hammering or rolling, but can be restored to its normal condition by annealing. It is easily brazed, and mixed with other metals it forms very valuable alloy, and corrodes but little under the action of sea water.

Strips cut longitudinally from copper pipes used in connection with Admiralty engines, must stand, after being annealed in water, not less than 13 tons per square inch, with a minimum elongation of 35 per cent. in 2 inches.

Strips cut from copper sheets or bars used in Admiralty ships are to have, after annealing in water, a tensile strength of 13 tons per square inch and an elongation of 30 or 35 per cent. in a length of 4 inches or 2 inches respectively. They are also to stand bending double, if unannealed, over a radius equal to the thickness (or diameter). If annealed, they must stand bending till the two sides meet, and hammering to a fine edge or point without cracking.

TIN.

Very malleable but only slightly ductile, and when bent gives a peculiar cracking noise. Principally used with other metals to form alloys, or as a protective covering to other metals liable to rust, as it is little affected by the action of the air or weak acids.

ZINC.

Brittle when cold, malleable when hot. Forms with other metals valuable alloys. It is little affected by the air or weak acids generally, and is therefore much used in coating metals to protect them from the action of the air or sea water.

BRONZE OR GUN METAL.

Strictly an alloy of copper and tin, but a little zinc is often added to increase the fusibility. Tin increases the hardness and mixes well in all proportions. With 2 parts of copper to 1 of tin an alloy is formed which cannot be cut with steel tools.

The maximum hardness for general purposes is obtained with 5 parts of copper to 1 of tin.

A good mixture consists of 90 parts of copper to $9\frac{1}{2}$ of tin.

All Admiralty gunmetal articles should, as nearly as possible, contain 88 parts copper, 10 parts tin, and 2 parts zinc. Only 8 per cent. of tin will be accepted, however, provided that there is not more than 5 per cent. zinc, and no appreciable admixture of lead.

Gunmetal articles should have a tensile strength of 14 tons per square inch, and an elongation in 2 inches of $7\frac{1}{2}$ per cent.

BRASS.

An alloy of copper and zinc, with a small quantity of tin sometimes added to increase the hardness or vary the colour.

Lead may be added to increase the ductility and make it more suitable for turning or filing. It is very malleable and easily worked cold, but not fit for forging at a red heat.

A good mixture for fine or yellow brass is 2 parts copper, 1 part zinc; used for ornamental castings, &c.

Admiralty brass must contain at least 63 per cent. of copper, and not more than 3½ per cent. of lead.

MUNTZ'S METAL.

Composed of 3 parts copper and 2 parts zinc. Has a very high tenacity, very ductile, and can be forged hot, and if hammered or rolled cold can be used for springs.

Much used for sheathing ships, and for engine bolts, &c., liable to rust.

NAVAL BRASS

Is Muntz's metal with about 1 per cent. of tin added. Resists the action of sea water whilst retaining all the other properties.

Can be forged hot, has a very high tenacity. Used for bolts of composite vessels, and for bolts exposed to sea water.

Admiralty composition, 62 per cent. of copper, 37 per cent. of zinc, and 1 per cent. of tin, and must have a tensile strength of 22 tons per square inch (and round bars under ¾ inch diameter 26 tons), with a minimum elongation of 10 per cent. in 2 inches or 4 inches. Also, (1) being hammered hot to a fine point, and (2) being bent cold to angle of 75° over radius equal to diameter of bar.

PHOSPHOR BRONZE.

Very hard, tough, close-grained alloy, composed of copper and tin with a small amount of phosphorus.

Very superior for bearings, wheels, &c., but if made hot is liable to crack.

Admiralty composition for bolts, &c., 90 per cent. copper, and 10 per cent. phosphor tin to contain about 5 per cent. of phosphorus.

DELTA METAL (NO. 1).

Very tough and malleable bronze. It produces sound, homogeneous castings. Can be readily forged. It is practically incorrodible in sea water, and it resists acids remarkably well.

Used for pumps and piston-rods, propellers, &c.; and will stand the following stresses:—Tensile strength: Wrought metal, 48·0 tons per sq. in.; cast metal, 41·3 tons per sq. in. Elongation: Wrought metal, 33 per cent. in length of 2 ins.; cast metal, 20 per cent. in length of 2 ins. Reduction of area, cast metal = 20·4 per cent.

The Delta Metal Company hold the Dick's patents for extruded metals.

The process consists of squeezing heated metals through dies of any desired shape by hydraulic pressure, producing not only a uniform section, but adding immensely to the strength and ductility of the metals so treated, as given in the table below:—

Alloy.	Rolled Bar.		Extruded Bar.	
	Tensile Strength. Tons per Sq. In.	Elongation, per Cent.	Tensile Strength. Tons per Sq. In.	Elongation, per Cent.
Delta metal, No. 1	45	20	48·1	33
" " No. 4	35·3	22	37·1	27

Manganese Bronze.

Very uniform close-grained bronze, with a proportion of ferro-manganese; can be rolled either hot or cold, very tough and strong, largely used for propeller blades, &c.

Aluminium Bronze.

Has nearly double the tenacity of gun metal, is not liable to rust, and can be forged either hot or cold; composed of 90 parts copper and 10 parts aluminium.

Babbit's White Metal.

Used for bearings; composed of 10 parts tin, 1 copper, and 1 antimony.

Fenton's White Metal.

Used for stern bushes, bushes for paddle wheels, &c.; fairly tough and hard, contains 8 parts zinc, 1·66 tin, and ·44 copper.

Lead.

Admiralty Test.—Sheet lead is to stand without injury cutting or bossing up, or any other usual test.

Lead pipe to stand the following water tests:—Up to $1\frac{1}{2}$ inch diameter 300 lbs. per square inch; above $1\frac{1}{2}$ inch and up to 4 inches, 200 lbs. per square inch. The pipe to have sufficient ductility to admit of turning or flanging at the ends to double the internal diameter without splitting.

BENDING MOMENTS, SHEARING FORCES, MOMENTS OF RESISTANCE AND DEFLECTION OF BEAMS.

Shearing Force.—At any section is the algebraical sum of all the forces acting between that section and either end of the beam.

Bending Moment.—At any section is the algebraical sum of all the shearing stresses acting between that section and either end of the beam.

Forces when acting downwards are to be taken as negative, and when acting upwards as positive, and the value of a formula being $\left\{\begin{matrix}\text{positive} +\\ \text{negative} -\end{matrix}\right\}$ shows that the action of the load tends to make the upper surface of the beam of a cantilever $\left\{\begin{matrix}\text{concave}\\ \text{convex}\end{matrix}\right\}$ and therefore compresses together the fibres in the $\left\{\begin{matrix}\text{upper}\\ \text{lower}\end{matrix}\right\}$ part and stretches them in the $\left\{\begin{matrix}\text{lower}\\ \text{upper}\end{matrix}\right\}$ part; the sum of the upward and downward forces must be equal.

Resultant Moments of the whole of the positive and negative forces acting on the beam about any point in the length of the beam must be zero.

Moment of Resistance to bending or cross-breaking at any point should at least equal the bending moment at that point, and in beams of uniform section the moment of resistance should at least equal the maximum bending moment with a suitable factor of safety (see p. 300).

Rule to find the bending moment at any loaded point when the beam is loaded with several concentrated weights :—

Multiply each shearing force by the length of the division on which it acts; then the bending moment at any given loaded point is equal to the algebraical sum of the products corresponding to the divisions which lie between that point and either end of the beam. (See graphical methods of showing this, pp. 279–283.)

Rule to find the moment of resistance to bending at any section :—

Multiply the geometrical moment of inertia of the effective area of the cross-section about its centre of gravity, by the tensile or compressive stress of the material, and divide this product by the distance of the most severely strained layer from the neutral axis of the section (that is, its centre of gravity). (For moments of inertia of sections see pp. 292–296.)

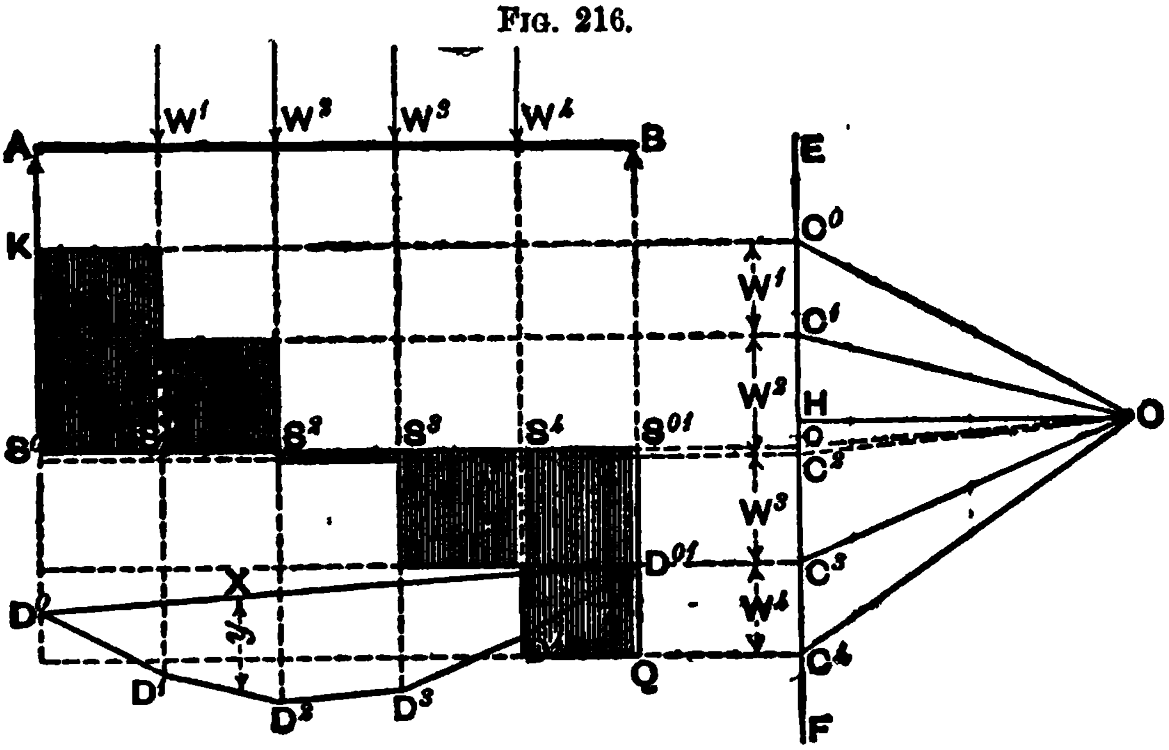
M = moment of resistance to cross-breaking in inch-lbs.
I = moment of inertia of section about centre of gravity in inches.
p = extreme tensile or compressive stress in lbs. per sq. inch.
y = distance of most severely strained layer from neutral axis.

$$M = \frac{pI}{y} \qquad p = \frac{My}{I} \qquad I = \frac{My}{p}$$

Graphical Method of Determining the Bending Moments and Shearing Forces in a Beam.

Concentrated Loads acting at various Points.

Fig. 216.



In fig. 216 AB represents the beam supported at points A and B. Set off continuously along a line EF, the forces W¹, W², W³, W⁴ = C⁰, C⁴, the resultant of the forces. Take any point O, and join

OC^0, OC^1, . . . OC^4, &c. Draw the parallel lines AD^0, WD^1, . . . BD^0 through the lines of action of the forces. Take any point, D^0 in AD^0, and draw D^0, D^1 parallel to OC^0, D^1, D^2 parallel to OC^1, . . . D^4, D^{01} parallel to OC^4. Join D^0, D^{01}, completing the funicular polygon D^0, D^3, D^{01}. Draw a line OC parallel to D^0, D^{01}, cutting EF in C; then C^0C equals the supporting force at A, and CC^4 equals the supporting force at B. Also through O draw OH perpendicular to EF.

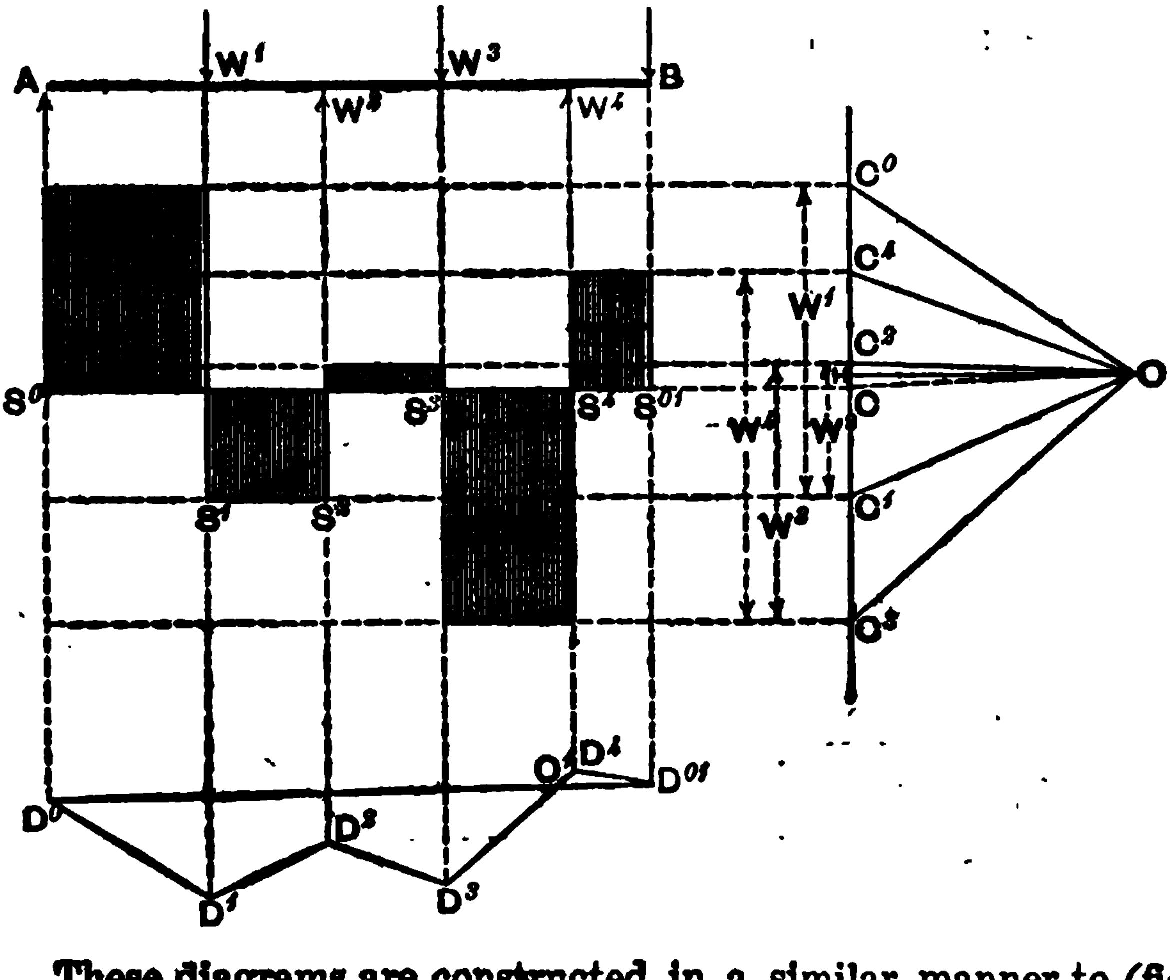
Through the points C^0, C^1, . . C^4 drop perpendiculars on to AD^0, W^1D^1, . . BD^{10}, and form the hatched figure $S^0KS^2QS^{01}$. Then the vertical ordinate of this diagram, measured at any point in the length of the beam, gives the shearing force at that point, measured on the same scale as used for setting off W^1, W^2, &c.

To obtain the bending moment at any point X make a scale as follows :—

If beam is drawn to a scale 1 foot $= x$ inches, and loads are drawn to a scale 1 pound $= z$ inches, then the ordinate 'y' of the funicular polygon is the bending moment at the point X on a scale such that 1 foot-pound is $= \frac{x \times y}{OH}$, in inches always; OH is measured on an inch scale.

Forces acting in different directions.

FIG. 217.



These diagrams are constructed in a similar manner to (fig. 216), the lengths of the forces being also set off in the direction

of their line of action. C^0C is the supporting force at A, and CC^4 the holding down force at B as it lies to the left of C—that is, it is measured in the opposite direction to C^0C^4; the bending moment at any point O^1 where the sides of the funicular polygon cross is zero, and the bending moments to the left of O^1 are in the opposite direction to those on the right of O^1.

Table of Graphical Bending Moments and Shearing Forces of Beams.

W = load. L = length of beam.

w = uniform intensity of load.

M = maximum bending moment.

m = bending moment at any section.

S_1 = maximum shearing force.

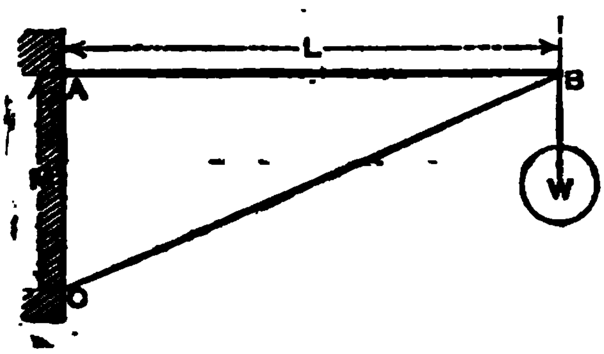
S = shearing force at any section.

The diagrams are constructed by setting off to scale M, and S_1, or S; then the ordinate measured at any point represents the moment or shearing force at that section.

Bending Moment	Shearing Force

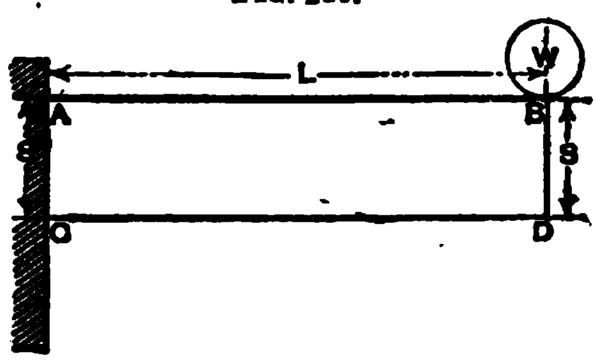
Fixed at one end, loaded at the other.

Fig. 218.



Set down M = WL, and join BC.

Fig. 219.



Set down S = W parallel to AC.

Table of Graphical Bending Moments, &c.—*cont.*

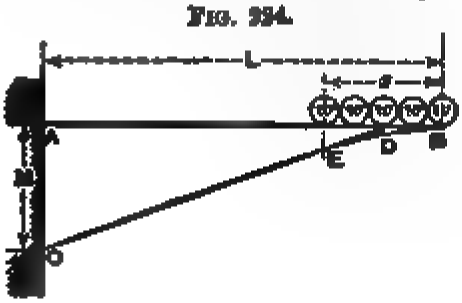
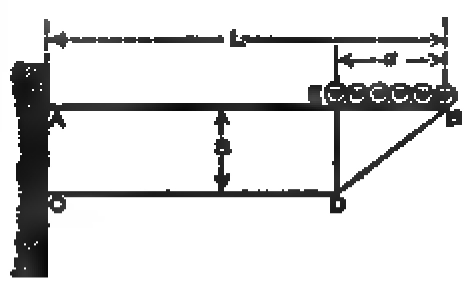
Bending Moments	Shearing Forces
Fixed at one end and loaded uniformly.	
Fig. 230.	Fig. 231.
Set off $M = \frac{wL^2}{2}$; draw the parabola BC, whose vertex is at B.	Set off $S_1 = wL$, and join BC.
Fixed at one end, uniformly loaded, with additional weight at one end.	
Fig. 232.	
Set off $M = WL$, and $M_1 = \frac{wL^2}{2}$. Join DB, and construct the parabola BC whose vertex is at B.	Set off $S = W$, and $S_1 = wL$. Join BC. Construct parallelogram ADEB.
Fixed at one end, partially uniformly loaded.	
Fig. 234. 	Fig. 235. 
Set off $M = wx\left(L - \frac{x}{2}\right)$. Join C to a point D at middle of load. Draw BE, a semiparabola, as for a beam uniformly loaded of a length x.	Set off the rectangle ACED, making $S = wx$, and join BD.

Table of Graphical Bending Moments, &c.—cont.

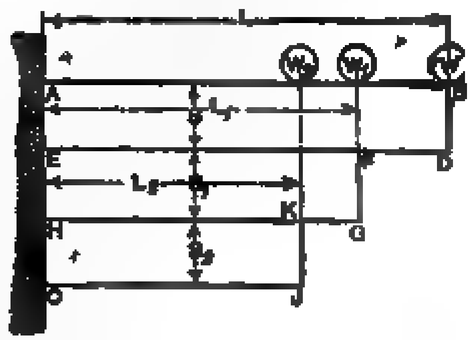
Bending Moments	Shearing Forces

Fixed at one end with several concentrated loads.

Fig. 226.

Set off $M = WL$, $M_1 = W_1L_1$, $M_2 = W_2L_2$. Join B to C, F to D, and E to H. The bending moment is equal to the sum of the bending moments at the section produced by each load separately.

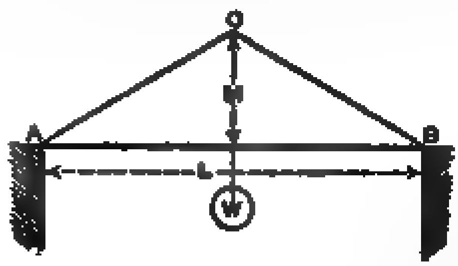
Fig. 227.



Set off $S = W$, $S_1 = W_1$, $S_2 = W_2$, and construct the rectangles ABDE, EFGH, and HKCJ.

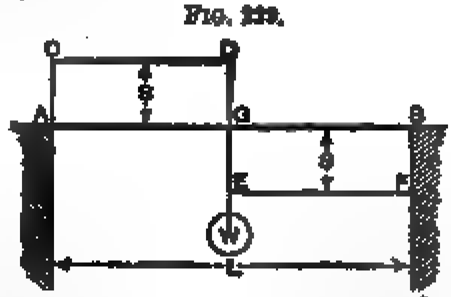
Supported at both ends, loaded at centre.

Fig. 228.



Set off $M = \frac{WL}{4}$. Join AC and BC.

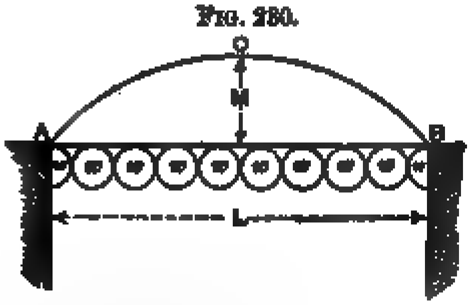
Fig. 229.



Set off S and $S = \frac{W}{2}$, and construct the rectangles ACDG and BGFE.

Supported at both ends, uniformly loaded.

Fig. 230.



Set off $M = \frac{wL^2}{8}$, and construct the parabola ACB, whose middle ordinate is at C.

Fig. 231.

$= \frac{wL}{2}$, and join DC.

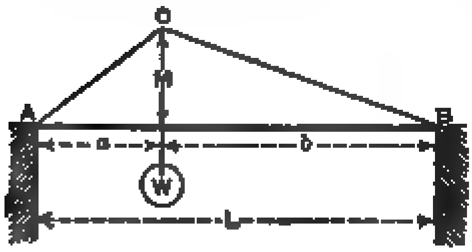
TABLE OF GRAPHICAL BENDING MOMENTS, &c.—*cont.*

Bending Moments	Shearing Forces

Supported at both ends, load out of centre.

Bending Moments

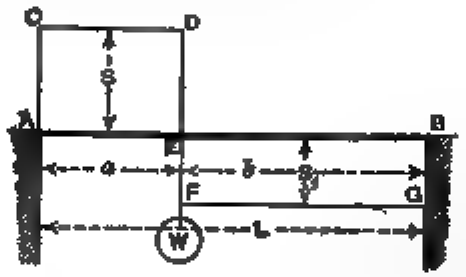
FIG. 282.



Set off $M = \frac{Wab}{L}$, and join AC and BC.

Shearing Forces

FIG. 283.

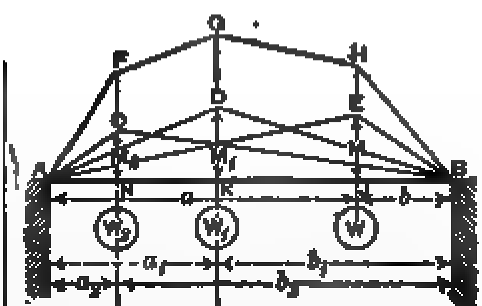


Set off $S = \frac{Wb}{L}$, and $S_1 = \frac{Wa}{L}$, and construct rectangles ACDE and HBGF.

Supported at both ends, unequally distributed loads.

Bending Moments

FIG. 284.



The bending moment at any point is equal to the sum of the bending moments produced at that point by each of the weights separately. Set off

$M = \frac{Wab}{L}$, $M_1 = \frac{W_1 a_1 b_1}{L}$, $M_2 = \frac{W_2 a_2 b_2}{L}$.

Then set up JH, KG, and NF, making the length for whole ordinates equal to the sum of the three ordinates at those points due to the several bending moments.

Shearing Forces

FIG. 285.

Set up

$$S = \frac{Wb + W_1 b_1 + W_2 b_2}{L},$$

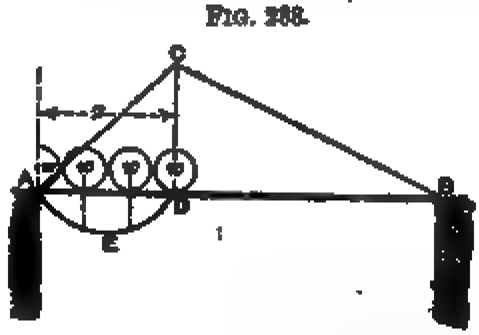
$$S_1 = \frac{Wb + W_1 b_1 + W_2 b_2}{L} - W_2,$$

$$S_2 = \frac{Wb + W_1 b_1 + W_2 b_2}{L} - W_2 - W_1,$$

$$S_3 = \frac{Wb + W_1 b_1 + W_2 b_2}{L} - W_2 - W_1 - W$$

$$= \frac{Wa + W_1 a_1 + W_2 a_2}{L}.$$

TABLE OF GRAPHICAL BENDING MOMENTS, &c.—*cont.*

Bending Moments	Shearing Forces
Supported at both ends, and partial uniform load not extending to either support.	
FIG. 236.	FIG. 237.
Set off CD at centre of load $=\frac{wzab}{L}$, and join AC and BC; at ends of z erect perpendiculars HF and EG, cutting AC and BC in H and E. Join D and E, then on z draw the parabola FGK, whose middle ordinate equals $\frac{wz^2}{8}$.	Set up $S=\frac{wz}{2L}(2L-2v-z)$, and $S_1=\frac{wz}{2L}(2v+z)$, and construct the diagram as in figure.
Supported at both ends, with partial uniform load extending to one sup.	
FIG. 238. 	
Set up $CD=\frac{wz(2L-z)}{2L}$; then draw underneath the parabola AED, whose ordinate at centre $=\frac{wz^2}{8}$.	and construct the diagram.

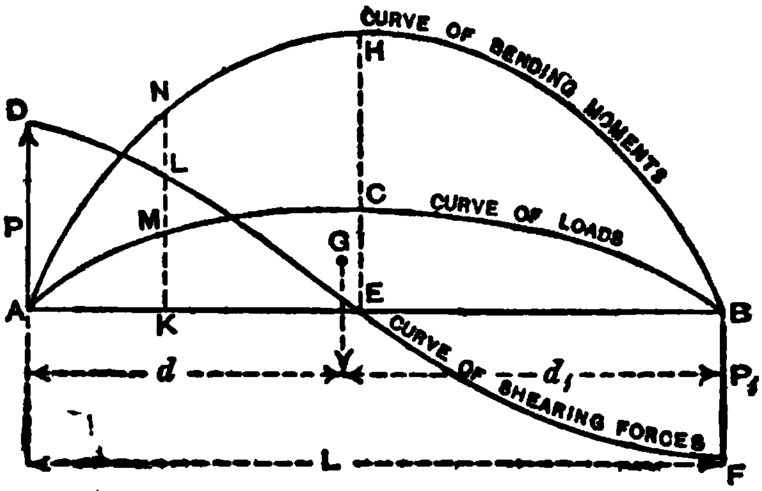
STRESSES IN VESSELS.

CURVES OF LOADS, BENDING MOMENTS, AND SHEARING FORCES.

Beam supported at both ends and loaded continuously, but unevenly distributed. (Fig. 240.)

Curve of Load.—Set up weight of load per unit of length, say in tons per foot, at suitable points in the length of the beam; a curve ACB then drawn through the points thus found will form the curve of loads whose area will equal the total load on the beam in tons.

FIG. 240.



Supporting Pressures.—Find the distance of the centre of gravity G of the area of curve of loads from either support. Then if

W = total load, P and P_1 = supporting pressures at A and B respectively, d and d_1 = distances of G from A and B respectively.

$$\text{Then } PL = Wd_1, \text{ and } P = \frac{Wd_1}{L};$$

$$P_1L = Wd, \text{ and } P_1 = \frac{Wd}{L}.$$

Shearing Stresses.—Set up AD at A = P, and set down BF at B = P_1. To find the shearing stress at any point K, calculate the area of the curve of loads from A to the point K = area of AMK, and deduct this from the supporting force P, and set this up as an ordinate, KL, of the shearing curve. At E a point will be reached where the difference between the curve of loads and the supporting force P will be zero; this spot is termed the point of reverse racking. The differences from this point on will be negative, and are to be set down below the line AB.

Bending Moment.—This is found in a similar way to the shearing curve, only the area of the shearing curve between the end of the beam and the section, say at K, is equal to the bending moment at that point. That is, the area ADKL is equal to the bending moment at the point K, and is set up as an ordinate, KN, of the curve.

The maximum bending moment comes at the point of reverse racking at E, and is equal to the area ADE; the shearing stresses from this point on, being negative, have to be deducted. The part area of the load curve ACE is equal to the supporting force AD.

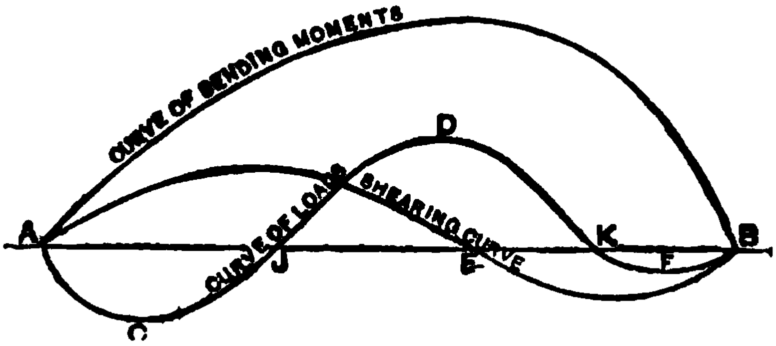
The part area of the load curve BCE is equal to the supporting force BF.

The direction in setting the curve of shearing stresses up or down is immaterial provided the correct relative signs are used.

DISTRIBUTED LOAD AND SUPPORT, SHIP FLOATING IN STILL WATER. (FIG. 241.)

Curve of Loads.—The intensity of load here employed is the *difference* between the intensity of the upward pressure of the water and the downward pressure of *total weight per unit of length*. If the buoyancy exceeds the downward pressure, set the ordinates above the line AB, and *vice versâ*.

FIG. 241.



The area of curve of loads JDK above the axis AB must equal the sum of the curves ACJ and BFK below the axis. The points J and K are termed water-borne sections, and may be looked upon as points of support.

Shear Curve.—Start from either end of the beam and set up the area of curve of loads from that end to the given section as an ordinate to the shearing curve; a curve passed through several points found in this manner will give the curve of shearing stresses.

Curve of Bending Moments.—Start from the end of the beam and find the area of the shearing curve between the given section and that end of the beam. This area will be an ordinate to the curve of bending moments at that point. Similar spots being found at other sections, these points are spots in the curve of bending moments.

Maximum bending moment at E is point of reverse racking. Maximum shearing is at the points J and K.

PRACTICAL CONSTRUCTION OF CURVES OF BENDING MOMENTS AND SHEARING FORCES OF VESSELS.

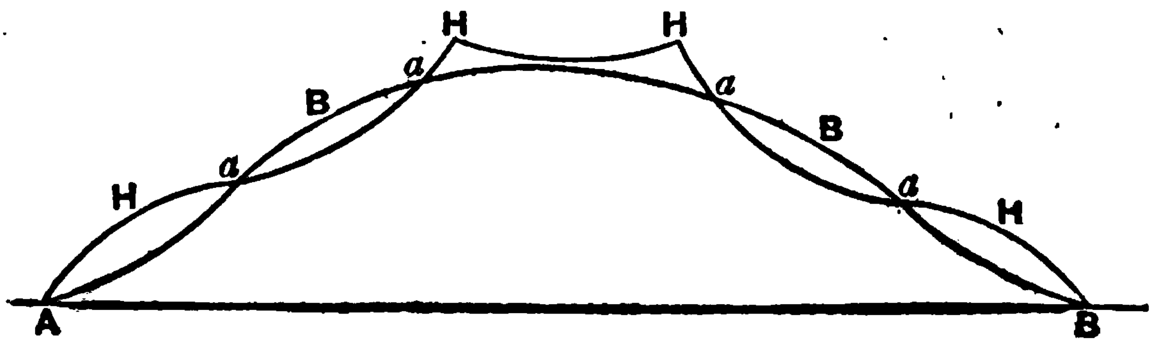
In Still Water. (Figs. 242 & 243.)

Curve of Buoyancy.—Take the displacement of the ship in tons per foot of length at convenient distances apart, and set them up as ordinates to the curve BBB from the axis AB. The area of the curve should equal the total displacement.

Curve of Weight of Hull and Lading.—Take the approximate weight of ordinary hull per foot of length, making a due allowance for a proportion of beams, carlings, rivet heads, &c., at convenient distances apart, and set them up from the axis AB as ordinates for the curve of weight of hull HHH. When heavy weights, such as armour, armour bulkheads, &c., are to be

taken into account they are best added on as rectangles, &c., above the ordinary hull curve ; and the same with the equipment and lading, such as engines, boilers, coals, cargo, &c. A curve

FIG. 242.

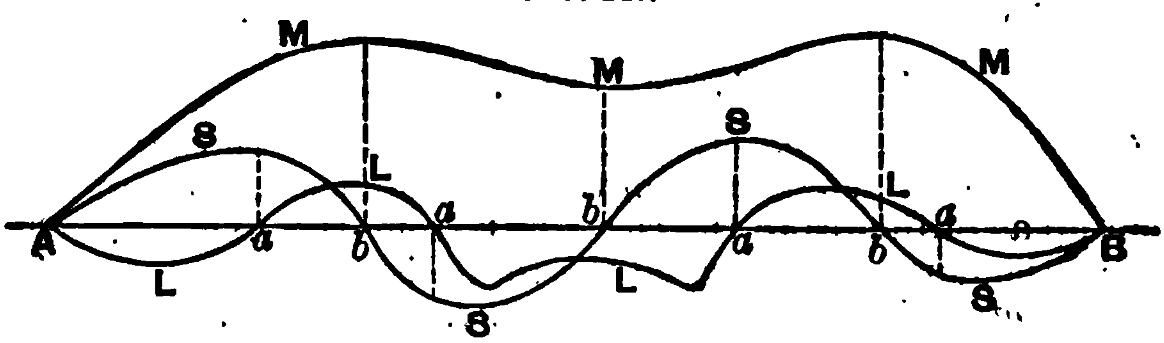


must then be made to approximate as closely as possible to this, taking care that its centre of gravity comes over the centre of buoyancy; or, in other words, the moments about the axis or any ordinate are the same as the moment of the actual irregular figure about the same axis or ordinate. The area of the curve will of course equal the buoyancy of the ship.

Curve of Loads.—From the two foregoing curves the curve of loads LLL (see fig. 243) is easily constructed. The difference between the ordinates to the curves being taken as ordinates for the curve of loads; where the weight is in excess it is set below the line, but where the buoyancy is in excess it is set above the line AB. The points *a*, *a*, *a*, &c., where the buoyancy equals the weight, are termed water-borne sections, and the area of curve below the axis must also equal the area above, and its centre of gravity must be vertically over the centre of buoyancy.

Curve of Shearing Stresses.—At any point is equal to the algebraical sum of all the stresses acting between that point and either end of the ship. The maximum shearing stresses are, therefore, always found at points *a*, *a*, *a* (see fig. 243), where the

FIG. 243.



curve of loads crosses the axis. To construct the curve, commence from the bow and find the area of the curve of loads at convenient distances up to that point, and set them up as ordinates for the curve marked SSS in figure, the areas above being

treated as positive, and those below as negative. There must always be an odd number of points where the shearing curve crosses the axis, termed points of reverse racking.

Curve of Bending Moments.—Is found from the curve of shearing stresses in a similar way to that in which the shearing curve was found from the curve of loads, it being remembered that the bending moment at any section is equal to the algebraical sum of all the shearing stresses between that section and either end of the beam, so that the maximum and minimum bending moments are always found at points where the shearing curve crosses the axis (see points *b*, *b*, *b* in fig. 243).

When the curve of bending moments is found to cross the axis it shows there is a sagging moment.

Stresses among Waves.—The calculations and curves are made in a similar way to the foregoing, but two cases are generally supposed—viz. (1) when the vessel is floating on the crest of a wave, and (2) when floating across the trough of a wave of an equal length to herself. But it requires experience to determine the exact water-line of the vessel, which has to be done tentatively, as the wave water-line in either case must cut off an amount of displacement equal to the weight of the vessel, and the centre of buoyancy of the displacement thus cut off must be in the same vertical line as the centre of gravity of the vessel. For depths of waves to correspond to lengths see pp. 123 and 124; and to construct a wave curve see p. 131.

For example of stress curves among waves see pp. 290 and 291.

Cross-breaking Strains.—The cross-breaking strain or moment of resistance at any section should at least equal the greatest bending moment at that point, with a sufficient factor of safety, say $\frac{1}{5}$ or $\frac{1}{6}$ the breaking strain of the material. Iron may be taken at 4 tons and steel 5 to 6 tons per square inch for maximum working stress.

Equivalent Girder.—Is a graphical method of showing the effective area of the section of material in a vessel grouped together about the middle line representing the decks, bulkheads, longitudinals, skin plating, &c., contributing to the longitudinal strength of a vessel. This section may then be treated as the section of any ordinary girder. To determine the stress in the upper and lower works from the ordinary formula $\frac{p}{y} = \frac{M}{I}$ see p. 296. The usual point at which to take the section is at a watertight frame or bulkhead and through any large hatchway, as being the weakest sections; in hogging strains the rivet holes below the neutral axis may be included in the effective area, while those above omitted, and in the case of sagging strains, *vice versâ*. But by omitting all the rivet holes in either case the error is on the right side and saves labour. The construction of the equivalent girder, as in fig. 245, explains itself, representing a section of an ordinary double-bottom vessel, with

middle line and coal bunker bulkheads; the area of the deck plating and planking and inner bottom plating and flat keel, &c., are represented in fig. 245 by the longitudinal flanges *a*, *b*, *c*, *d*, &c., while the side plating, middle line bulkheads, coal bunker bulkheads, &c., are represented by the webs. In iron or steel work for watertight work $\frac{1}{5}$, and non-watertight work $\frac{1}{10}$ is deducted from the total area for the effective area; and for wood decks $\frac{3}{8}$ of the area is deducted, and the effective area then divided by 6 to bring it to the equivalent strength of iron, and by 7·5 to 8 for steel.

FIG. 244.

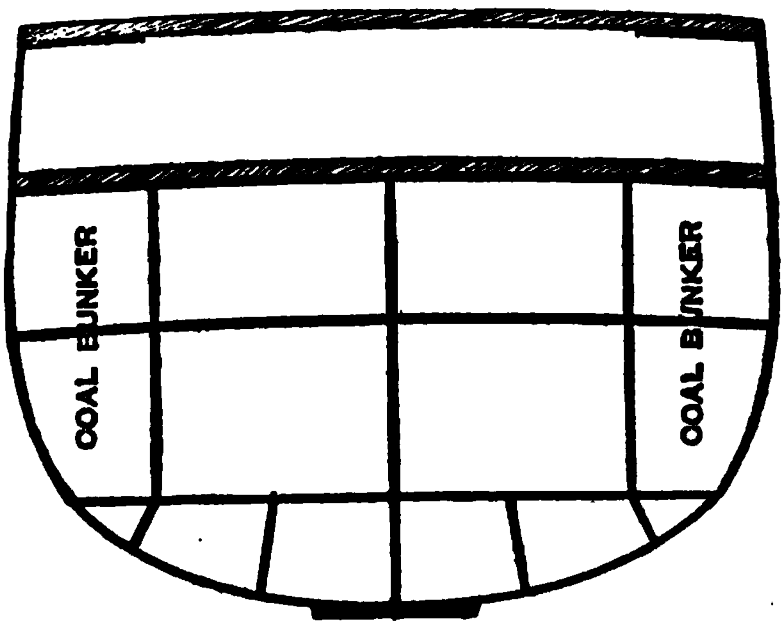


FIG. 245.

The table on p. 289 gives an example of the usual method of obtaining the moment of inertia of the section, from a paper by W. H. White, Esq., published in the XVIII. Vol. of *Trans. Inst. Naval Architects.*

MOMENT OF INERTIA OF A SECTION ABOUT PARALLEL AXES.

A = area of section.

I_0 = moment of inertia about neutral axis.

I = moment of inertia about parallel axis distant y from neutral axis.

$$I = I_0 + Ay^2. \quad I_0 = I - Ay_2.$$

Calculation of Moment of Inertia of Section when the Ship is under a Hogging Strain.

Part of Structure	Effective Sectional Area = A	Distance of Centre of Gravity from Neutral Axis = h	Squares of Distances = h^2	Products $A \times h^2$	Depths of Webs in Girder = d	Squares of Depths = d^2	Products $\frac{1}{12} \times A \times d^2$
	Sq. Ins.	Feet			Feet		
Upper deck flange . .	155·1	19·2	368·6	57170	—	—	—
Main deck flange . .	654·1	10·6	112·4	73521	—	—	—
Lower deck flange . .	117·2	3·6	13·0	1524	—	—	—
Wing passage bulkd. (port)	51·0	5·5	30·2	1540	9·0	81	344
Coal bunker bulkhd. (port)	14·0	1·4	2·0	28	2·8	7·8	9
Shelf plate . . .	24·7	·85	·7	17	—	—	—
Skin plating . . .	685·1	10·1	102·0	69880	18·4	338·6	19331
Bottom plating above neutral axis	19·0	·4	·2	4	·8	·6	1
Coal bunker bulkhead (lower part)	37·8	3·2	10·2	386	6·3	39·7	125
Wing passage bulkhead (lower part)	63·4	4·6	21·2	1344	9·3	86·5	457
Bottom plating (above bilge)	401·0	7·5	56·3	22576	12·7	161·3	5390
Bottom flange . . .	889·0	15·8	249·6	221894	5·5	30·2	2237
				449884			27894
				27894			
			I = moment of inertia	477778			

Total depth of girder = 37·5 Feet
Neutral axis below top $= y_1 = 19·3$
" " above bottom $= y_2 = 18·2$

When the ship is on a wave crest,
M = bending moment at section just outside battery = 28000 foot-tons.

Maximum tensile strain on upper part of section

$$= \frac{28000 \text{ (Foot-tons)} \times 19·3 \text{ (Feet)}}{477778} = 1·13 \text{ tons per square inch.}$$

Maximum compressive strain on lower part of section

$$= \frac{28000 \times 18·2}{477778} = 1·07 \text{ tons per square inch.}$$

Note.—The method of obtaining the moment of inertia as shown in the above table is based upon rule on p. 288, and that the moment of inertia of a rectangle above its centre of gravity is equal to its area multiplied by $\frac{1}{12}$ the square of its depth; but this rule is not applied to the flanges where the depth is so very small, but simply $A \times h^2$ is taken.

Table of Maximum Tension on Upper Works of Vessels of Various Sizes.*

Tonnage of Vessels	Maximum Tension on the Upper Works in Tons per Square Inch	Tonnage of Vessels	Maximum Tension on the Upper Works in Tons per Square Inch
100	1·67	800	4·59
200	2·36	900	4·8
300	3·09	1000	5·19
400	3·55	1500	5·34
500	3·95	2000	5·9
600	3·72	2500	7·08
700	4·57	3000	8·09

Bending Moments of Vessels expressed as Fractions of their Weight into their Length.

Maximum Bending Moment	'Minotaur'	'Devastation'	'Bellerophon'	'Victoria and Albert'
On a wave crest } hogging	[illegible] × W × L	[illegible] × W × L	[illegible] × W × L	[illegible] × W × L
In wave hollow } sagging	[illegible] × W × L	[illegible] × W × L	[illegible] × W × L	[illegible] × W × L
In still water .	[illegible] × W × L hogging	[illegible] × W × L sagging	[illegible] × W × L hogging	[illegible] × W × L sagging

Actual Curves of Bending Moments, &c., of an Armoured Turret Ram.

Fig. 246.

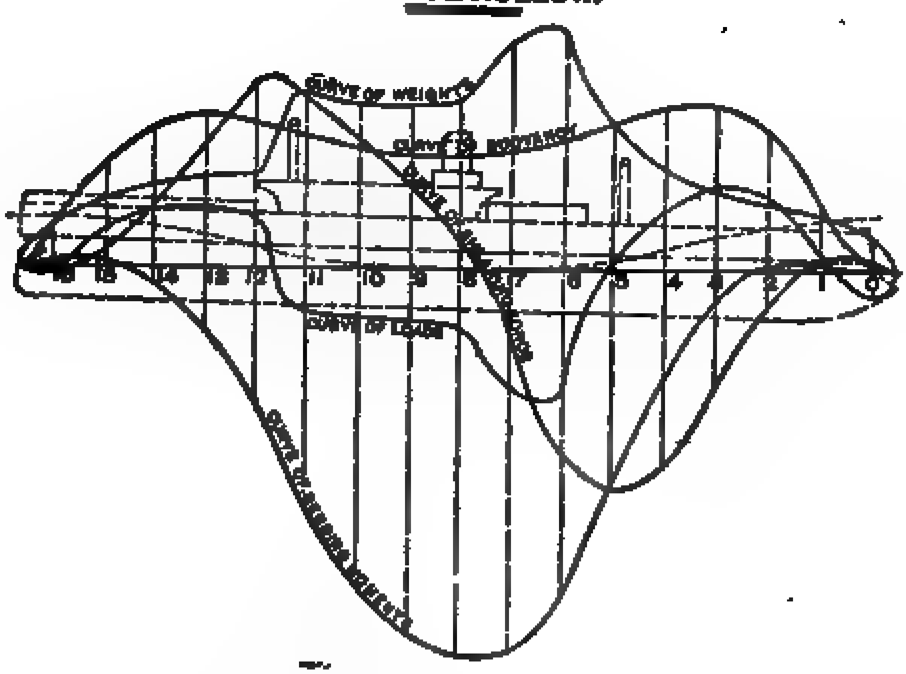
IN STILL WATER.

* From 'Trans. Inst. of Naval Architects,' Vol. XV., from article by W. John, Esq., M.I.N.A.

FIG. 247.

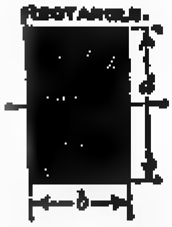
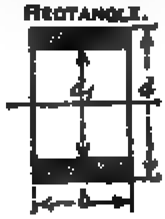
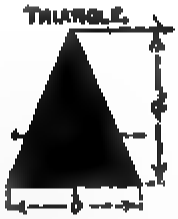
FIG. 248.*

IN WAVE HOLLOW.



* From 'Transactions of the Institute of Naval Architects,' Vol. XVIII., from article by W. H. White, Esq., M.I.N.A.

FIG. 249.*

Table of Moments of Inertia and Resistance of various Sections.		
Form of Section	**Moment of Inertia through Centre of Gravity**	**Moment of Resistance = M**
RECTANGLE. 	$\frac{bd^3}{12}$	$p\frac{bd^2}{6}$
RECTANGLE. 	$\frac{b}{12}\left(d^3-d_1^3\right)$	$p\left\{\frac{b}{6d}\left(d^3-d_1^3\right)\right\}$
TRIANGLE. 	$\frac{bd^3}{36}$	$p\frac{bd^2}{24}$

* Taken from 'Transactions of the Institute of Naval Architects,' from an article by W. H. White, Esq., M.I.N.A., on the 'Structural Arrangements and Proportions of H.M.S. "Iris,"' Vol. XX.

TABLE OF MOMENTS OF INERTIA, &c.—*cont.*

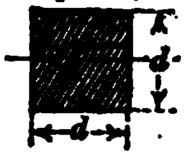
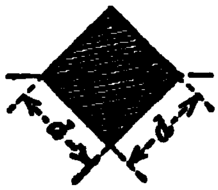
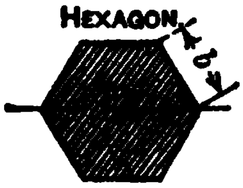
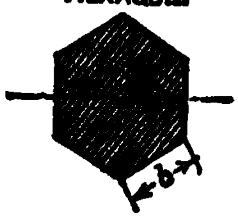
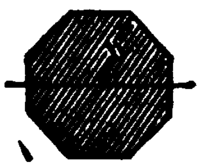
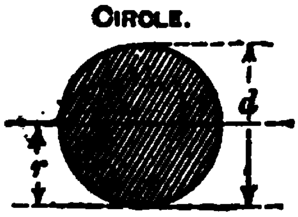
Form of Section	Moment of Inertia through Centre of Gravity	Moment of Resistance $= M$
SQUARE. 	$\dfrac{d^4}{12}$	$p\dfrac{d^3}{6}$
SQUARE. 	$\dfrac{d^4}{12}$	$\cdot 118pd^3$
HEXAGON. 	$\dfrac{5}{16}b^4\sqrt{3}$ $=\cdot 5413b^4$	$\dfrac{5}{8}pb^3=\cdot 625pb^3$
HEXAGON. 	$\dfrac{5}{16}b^4\sqrt{3}$ $=\cdot 5413b^4$	$\dfrac{5}{16}pb^3\sqrt{3}=\cdot 5413pb^3$
OCTAGON. 	$\dfrac{1+2\sqrt{2}}{6}b^4$ $=\cdot 638b^4$	$\cdot 6906pb^3$
Regular polygon with n sides. $b=$ side. $r=$ radius of circumscribed circle. $a=$ area $=\dfrac{nr^2}{2}\sin.\dfrac{2\pi}{n}$.	$\dfrac{a}{12}\left(3r^2-\dfrac{b^2}{2}\right)$	$p\dfrac{ra}{4}$
CIRCLE. 	$\dfrac{\pi d^4}{64}=\cdot 0491d^4$ $=\dfrac{\pi r^4}{4}=\cdot 7854r^4$	$p\dfrac{\pi d^3}{32}=\cdot 0982pd^3$ $=p\dfrac{\pi r^3}{4}=\cdot 7854pr^3$

Table of Moments of Inertia, &c.—*cont.*

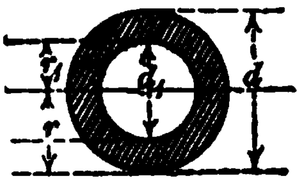
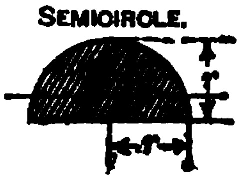
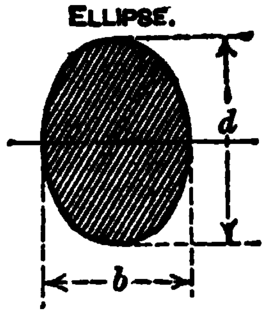
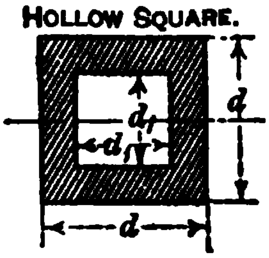
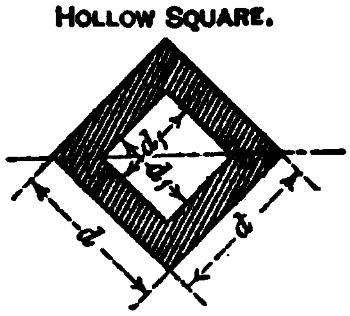
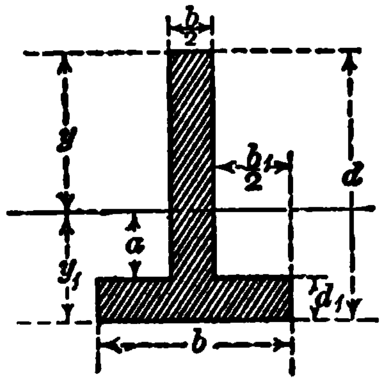
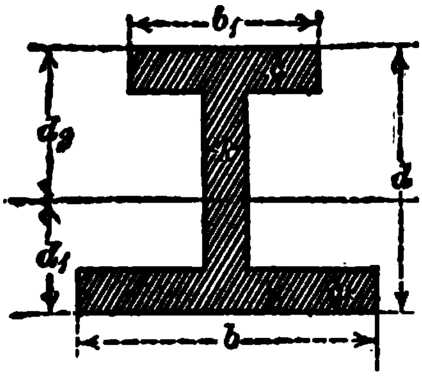
Form of Section	Moment of Inertia through Centre of Gravity	Moment of Resistance $=M$
HOLLOW CIRCLE. 	$\frac{\pi}{64}(d^4-d_1^4)$ $=\frac{\pi}{4}(r^4-r_1^4)$	$\frac{\pi}{32}\left(\frac{d^4-d_1^4}{d}\right)p$ $\frac{\pi}{4}\left(\frac{r^4-r_1^4}{r}\right)p$
SEMICIRCLE. 	$\cdot110d^4$	$\cdot19pr^3$
HOLLOW SEMICIRCLE. 	$\cdot110(r^4-r_1^4)-\frac{\cdot283r^2r_1^2(r-r_1)}{r+r_1}$	$\frac{pI}{y}$
ELLIPSE. 	$\frac{\pi bd^3}{64}=\cdot0491bd^3$	$\frac{\pi bd^2}{32}p=\cdot0982pbd^2$
HOLLOW SQUARE. 	$\frac{d^4-d_1^4}{12}$	$\frac{1}{6}\left(\frac{d^4-d_1^4}{d}\right)$
HOLLOW SQUARE. 	$\frac{d^4-d_1^4}{12}$	$p\left(\frac{d^4-d_1^4}{12d}\right)\sqrt{2}$ $=\cdot1178\left(\frac{d^4-d_1^4}{d}\right)p$

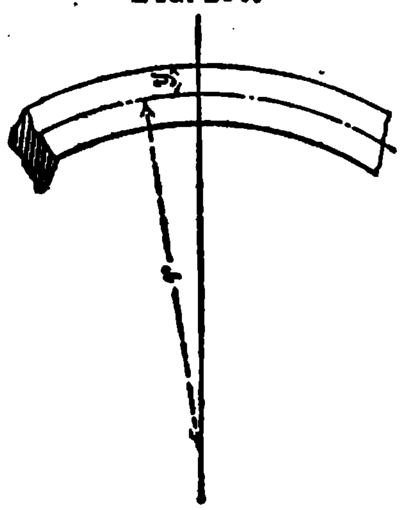
TABLE OF MOMENTS OF INERTIA, &c.—*cont.*

Form of Section	Moment of Inertia through Centre of Gravity	Moment of Resistance $=$ M
	$\frac{1}{3}\left\{ \begin{matrix} by_1^3 - b_1a^3 \\ + b_2y^3 \end{matrix} \right\}$	$p\frac{I}{y}$
	$\frac{1}{3}\left\{ \begin{matrix} bd_1^3 - (b-k)(d_1-c_1)^3 + b_1d_2^3 \\ -(b_1-k)(d_2-c^3) \end{matrix} \right\}$	

General Expressions for applying the above Table.

Let M = greatest bending moment, and also moment of resistance.
y = distance of neutral axis from part under greatest stress.
p = greatest tensile or compressive stress on unit of cross section.
I = moment of inertia of cross section.
E = modulus of elasticity of material.
r = radius of curvature.

FIG. 250.



Then
$$\frac{p}{y} = \frac{M}{I} = \frac{E}{r}$$
$$M = \frac{pI}{y} = \frac{EI}{r}$$
$$p = \frac{My}{I} = \frac{Ey}{r}$$
$$E = \frac{pr}{y} = \frac{Mr}{I}$$
$$r = \frac{EI}{M} = \frac{Ey}{p}$$

Note.—All measurements to be taken in inches or pounds as required.

TABLE OF MOMENTS OF INERTIA AND CONSTANTS FOR MOMENTS OF RESISTANCE FOR CIRCULAR SECTIONS ●.

Diameter in Inches	Moment of Inertia	Constants for Moment of Resistance	Diameter in Inches	Moment of Inertia	Constants for Moment of Resistance	Diameter in Inches	Moment of Inertia	Constants for Moment of Resistance
1	0·0491	0·0982	35	73662	4209	69	1112660	32251
2	0·7854	0·7854	36	82448	4580	70	1178588	33674
3	3·976	2·651	37	91998	4973	71	1247393	35138
4	12·57	6·283	38	102354	5387	72	1319167	36644
5	30·68	12·27	39	113561	5824	73	1393995	38192
6	63·62	21·21	40	125664	6283	74	1471963	39783
7	117·9	33·67	41	138709	6766	75	1553156	41417
8	201·1	50·27	42	152745	7274	76	1637662	43096
9	322·1	71·57	43	167820	7806	77	1725571	44820
10	490·9	98·17	44	183984	8363	78	1816972	46589
11	718·7	130·7	45	201289	8946	79	1911967	48404
12	1018	169·6	46	219787	9556	80	2010619	50265
13	1402	215·7	47	239531	10193	81	2113051	52174
14	1886	269·4	48	260576	10857	82	2219347	54130
15	2485	331·3	49	282979	11550	83	2329605	56135
16	3217	402·1	50	306796	12272	84	2443920	58189
17	4100	482·3	51	332086	13023	85	2562392	60292
18	5153	572·6	52	358908	13804	86	2685120	62445
19	6397	673·4	53	387323	14616	87	2812205	64648
20	7854	785·4	54	417393	15459	88	2943748	66903
21	9547	909·2	55	449180	16334	89	3079853	69210
22	11499	1045	56	482750	17241	90	3220623	71569
23	13737	1194	57	518166	18181	91	3366165	73982
24	16286	1357	58	555497	19155	92	3516586	76448
25	19175	1534	59	594810	20163	93	3671992	78968
26	22432	1726	60	636172	21206	94	3832492	81542
27	26087	1932	61	679651	22284	95	3998198	84173
28	30172	2155	62	725332	23398	96	4169220	86859
29	34719	2394	63	773272	24548	97	4345671	89601
30	39761	2651	64	823550	25736	98	4527664	92401
31	45333	2925	65	876240	26961	99	4715315	95259
32	51472	3217	66	931420	28225	100	4908738	98175
33	58214	3528	67	989166	29527			
34	65597	3859	68	1049556	30869			

For use see pp. 267 and 296.

Table of Moments of Inertia and Constants for Moments of Resistance for Hollow Tubular Sections.

External Diameter in Inches	Thickness in Inches								
	1·2	1·5	1·8	2·0	2·2	2·5	2·8	3·0	3·5
10	327·1 65·42	373·0 74·59	408·5 81·70	427·3 85·45					
11	405·2 81·85	517·6 94·11	571·5 103·9	600·8 109·2	625·6 113·8				
12	601·0 100·2	695·8 116·0	773·5 128·9	816·8 136·1	854·1 142·4	900·0 150·0			
13	782·3 120·3	911·1 140·2	1019 156·8	1080 166·1	1134 174·4	1201 184·8			
14	996·9 142·4	1167 166·7	1311 187·4	1395 199·3	1469 209·9	1564 223·4			
15	1248 166·4	1467 195·6	1656 220·8	1766 235·5	1866 248·8	1994 265·9	2102 280·2		
16	1538 192·2	1815 226·9	2056 257·1	2199 274·9	2329 291·1	2498 312·3	2643 330·3		
17	1869 219·9	2214 260·5	2517 296·1	2698 317·4	2863 336·8	3082 362·6	3271 384·8	331 397·3	
18	2246 249·5	2668 296·4	3042 338·0	3267 363·0	3475 386·1	3751 416·8	3992 443·6	4135 459·5	
19		3180 334·8	3636 382·8	3912 411·8	4168 438·7	4511 474·9	4814 506·8	4995 525·8	
20		3754 375·4	4308 430·8	4687 468·7	4948 494·8	5369 536·9	5743 574·3	5968 596·8	6452 645·2
22·5			6319 561·7	6831 607·2	7311 650·0	7977 709·0	8575 762·3	8942 794·9	9747 866·4
25			8880 710·4	9628 770·2	10334 827·0	11320 905·7	12222 977·7	12778 1022	14022 1122
27·5				13602 952·9	14095 1025	15498 1127	16782 1221	17585 1279	19397 1411
30				17327 1155	18676 1246	20586 1372	22359 1491	23472 1565	26021 1735
32·5				22377 1377	24157 1487	26688 1643	29058 1788	30554 1880	34005 2093
35				28325 1619	30619 1750	33896 1937	36988 2114	38938 2225	43484 2485
37·5				35245 1880	38145 2035	42301 2256	46237 2466	48736 2599	54598 2912
40				43210 2161	46818 2341	51995 2600	56917 2846	60058 3003	67440 3372

Note.—The first figures given are the moments of inertia, and the second the constants for moments of resistance. See pp. 267 and 296.

RESISTANCE OF THIN HOLLOW CYLINDERS AND SPHERICAL SHELLS TO BURSTING.

P = bursting pressure in lbs. per square inch.
T = tensile strength of material in lbs. per square inch.
t = thickness of material in inches.
r = radius in inches.

For Thin Hollow Cylinders.

$$P = \frac{Tt}{r} \qquad t = \frac{Pr}{T}$$

For Thin Spherical Shells.

$$P = \frac{2Tt}{r} \qquad t = \frac{Pr}{2T}$$

RESISTANCE OF THICK HOLLOW CYLINDERS AND SPHERICAL SHELLS TO BURSTING.

P = bursting pressure in lbs. per square inch.
T = tensile strength of materials in lbs. per square inch.
R = external radius in inches.
r = internal radius in inches,

For Thick Hollow Cylinders.

$$P = \frac{T(R^2 - r^2)}{R^2 + r^2} \qquad R = r\sqrt{\frac{(T + P)}{(T - P)}} \qquad r = R\sqrt{\frac{(T - P)}{(T + P)}}$$

For Thick Spherical Shells.

$$P = \frac{2T(R^3 - r^3)}{R^3 + 2r^3} \qquad R = r\sqrt[3]{\frac{2(T + P)}{(2T - P)}} \qquad r = R\sqrt[3]{\frac{(2T - P)}{2(T + P)}}$$

TENACITY OF WROUGHT-IRON RIVETED JOINTS IN LBS. PER SQUARE INCH OF ENTIRE PLATE.

Double-riveted. Diameter of each hole = $\frac{3}{10}$ of distance from centre to centre of holes = 35,700 lbs.
Single-riveted = 28,600 lbs.

RESISTANCE OF WROUGHT-IRON TUBES TO COLLAPSING.

P = collapsing pressure in lbs. per square inch.
L = length of tube in inches.
d = diameter in inches.
t = thickness of metal in inches.

$$P = \frac{9672000t^2}{Ld}$$

Resilience of Tie Bars.

S = proof stress.
E = modulus of elasticity (see pp. 329, 330).
A = sectional area.
L = length.
R = resilience of bar.
m = modulus of resilience.

$$R = \frac{S^2AL}{2E} \qquad m = \frac{S^2}{E}$$

Table of Examples of Moduli of Resilience.

Material	Proof Stress in Lbs. per Square Inch	Modulus of Elasticity	Modulus of Resilience
Bar iron	20,000	28,000,000	14·3
Cast „	5,500	17,000,000	1·8
Iron wire	30,000	25,000,000	36·0
Steel	36,000	28,000,000	46·3

Factors of Safety.

D = dead load.
L = live load.
F = factor of safety for mixed live and dead load.
B = breaking load.
P = proof load.
W = working load.
K = factor of safety for dead load.
C = factor of safety for live load.

$$F = \frac{DK + CL}{D + L} \qquad P = \frac{B}{K} \qquad B = WF$$

Table of Examples of Factors of Safety.
B = breaking load. P = proof load. W = working load.

Material	B÷P	B÷W	P÷W	Kind of Load
Strongest steel	$1\frac{1}{2}$	—	—	—
Ordinary steel and Wrought iron	2	3	$1\frac{1}{2}$	Dead load
	2	4 to 6	2 to 3	Live „
Wrought-iron riveted structures	3	6	2	—
Cast iron	2 to 3	3 to 4	$1\frac{1}{2}$	Dead load
	3	6 „ 8	2 to 3	Live „
Timber, average	3	10	$3\frac{1}{2}$	—

Resistance of Pillars to Crushing by Bending.

(*Rankine.*)

P = breaking load of pillar in lbs.
A = sectional area of material in square inches.
L = length in feet.
r = least radius of gyration of cross section in feet (see following table).
k and c = coefficients.

$$P = \frac{kA}{1 + \frac{L^2}{cr^2}} \text{ fixed at both ends.}$$

$$P = \frac{kA}{1 + \frac{4L^2}{cr^2}} \text{ jointed at both ends.}$$

$$P = \frac{kA}{1 + \frac{16L^2}{9cr^2}} \text{ jointed at one end and fixed at the other.}$$

Value of Coefficients in Lbs. per Square Inch.

	Values of k.	Values of c.
Malleable iron . . .	36,000	36,000
Cast iron	80,000	6,400
Dry timber	7,200	3,000

Table of the Values of the Square of the Least Radius of Gyration for Special Figures.

Solid Rectangle.	H *Iron.*	*Angle Iron.*
 $R^2 = \frac{b^2}{12}$	 Area of flanges = A. Area of web = B. $R^2 = \frac{Ab^2}{12(A+B)}$	 $R^2 = \frac{h^2 \times b^2}{12(h^2+b^2)}$
Thin Hollow Rectangle.	*Cross Iron.*	*Round Iron.*
 $R^2 = \frac{h^2(h+3b)}{12(h+b)}$	 $R^2 = \frac{h^2}{24}$	 $R^2 = \frac{d^2}{16}$
Thin Hollow Square.	*Channel Iron.*	*Tube Iron.*
 $R^2 = \frac{h^2}{6}$	 A = area of flanges. B = area of web. t = thickness of web. $R^2 = \left\{\left(\frac{2h+t}{2}\right)^2 \times \left(\frac{A}{12A+12B} + \frac{AB}{4(A+B)^2}\right)\right\}$	 $R^2 = \frac{d^2}{8}$

Table of the Strength of Long Columns whose Length exceeds Thirty Times their Diameter.

W = breaking weight in tons. L = length in feet. D = external diameter in inches. d = internal diameter in inches.

Kind of Column	Both Ends Rounded	Both Ends Flat
Hollow cast-iron cylindrical pillars	$W=13\dfrac{D^{3\cdot76}-d^{3\cdot76}}{L^{1\cdot7}}$	$W=44\cdot34\dfrac{D^{3\cdot55}-d^{3\cdot55}}{L^{1\cdot7}}$
Solid cast-iron cylindrical pillars	$W=14\cdot9\dfrac{D^{3\cdot76}}{L^{1\cdot7}}$	$W=44\cdot16\dfrac{D^{3\cdot55}}{L^{1\cdot7}}$
Solid wrought-iron cylindrical pillars	$W=42\cdot8\dfrac{D^{3\cdot76}}{L^{2}}$	$W=133\cdot75\dfrac{D^{3\cdot55}}{L^{2}}$
Solid square pillars of dry deal	—	$W=7\cdot81\dfrac{D^{4}}{L^{2}}$
Solid square pillars of dry Dantzic oak	—	$W=10\cdot95\dfrac{D^{4}}{L^{2}}$

Strength of Short Columns.

W = breaking weight of long column of same diameter.

w = breaking weight of short column.

C = crushing force of materials in tons × sectional area of column.

$$w = \frac{WC}{W + \frac{3}{4}C}$$

Riveted Joints.

t = thickness of plate in inches.

d = diameter of rivet in inches.

p = pitch or distance from centre to centre of rivet in inches.

n = number of rows of rivets.

$$p = d + \frac{\cdot7854nd^2}{t}$$

$$n = \frac{(p - d)t}{\cdot7854d^2}$$

Note.—Each plate is weakened by the rivet holes in the ratio

$$\frac{p - d}{p} = \frac{\cdot7854nd}{t + \cdot7854nd}.$$

Table of Dimensions of Rivets generally Used.

Thickness of Plates in Inches	Diameter of Rivets in Inches			London		
	Lloyd's	Liverpool Registry	Admiralty	Diameter of Rivets in Inches	Length Counter-sunk in Inches	Length Snap Points in Inches
$\frac{5}{16}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	$1\frac{1}{8}$	$1\frac{1}{2}$
$\frac{3}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$1\frac{1}{4}$	$1\frac{5}{8}$
$\frac{7}{16}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{5}{8}$	$1\frac{1}{8}$	$1\frac{3}{4}$
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$1\frac{1}{2}$	2
$\frac{9}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{3}{4}$	$1\frac{11}{16}$	$2\frac{3}{16}$
$\frac{5}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$1\frac{15}{16}$	$2\frac{3}{8}$
$\frac{11}{16}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$2\frac{3}{16}$	$2\frac{5}{8}$
$\frac{3}{4}$	$\frac{7}{8}$	1	1	$\frac{7}{8}$	$2\frac{3}{8}$	$2\frac{3}{4}$
$\frac{13}{16}$	$\frac{7}{8}$	1	1	$\frac{7}{8}$	$2\frac{1}{2}$	$2\frac{7}{8}$
$\frac{7}{8}$	1	1	$1\frac{1}{8}$	1	$2\frac{5}{8}$	3
$\frac{15}{16}$	1	$1\frac{1}{16}$	$1\frac{1}{8}$	1	$2\frac{3}{4}$	$3\frac{1}{8}$
1	1	$1\frac{1}{8}$	$1\frac{1}{8}$	1	$2\frac{7}{8}$	$3\frac{1}{4}$

Note.—Lloyd's require a spacing of 4 to $4\frac{1}{2}$ diameters.
Liverpool Registry require a spacing of 4 diameters.
Admiralty require a spacing of $4\frac{1}{2}$ to 5 diameters in edges and butts of bottom plating and bulkhead plating, and 5 to 6 diameters in water-tight work elsewhere.
Veritas require a spacing of 4 diameters for single-riveting and $4\frac{1}{2}$ diameters for double-riveting.

Notes on Riveted Joints.

1. A closer pitch of rivets should be adopted in single- than in double-riveted butts and in double- than in treble-riveted butts.

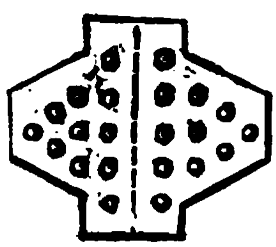
2. With a 4-diameter pitch the efficiency of a single-riveted butt is very small.

3. With a 4-diameter pitch the strength of a double-riveted butt is about at the maximum when the plates are not more than $\frac{1}{2}$ in. thick.

4. When plates are more than $\frac{3}{4}$ in. thick larger rivets should be put in than those generally in use.

Butt Straps.

FIG. 251.



In joints of the character shown in the diagram the strength of the plates joined is only weakened to the extent caused by cutting away a width equal to the diameter of one rivet.

Relative Tenacity of Riveted Joints.

	Rivet Holes Deducted.	Rivet Holes Included.
Continuous plate . . .	100	100
Double-riveted joint . . .	100	70
Single-riveted „ . . .	79	56

Resistance to Shearing.

In plate and rivet iron the resistance is nearly equal to the tensile strength. In metals such as cast iron it is somewhat greater than the tensile strength. In timber it is nearly equal to the tenacity across the grain.

Modulus of Elasticity.

To Determine the Modulus of Elasticity from Extension or Compression.

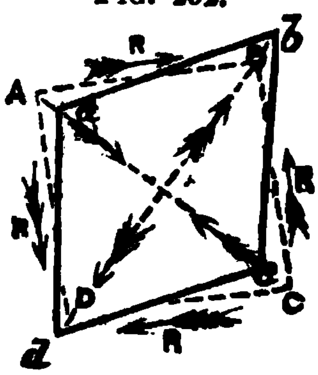
E = modulus of elasticity (for values see pp. 329, 330).
A = area of section in square inches.
L = length of materials in feet.
W = load applied in lbs.
l = elongation or compression in feet.

$$E = \frac{WL}{Al} \qquad W = \frac{EAl}{L} \qquad l = \frac{WL}{EA}$$

Table of Different Kinds of Load and Stress.
(*Rankine.*)

		Load and Stress	Strain	Stiffness	Pliability	Way of Breaking	Strength
Direct		Pull or tension	Stretch or extension	Resistance to extension	Direct extensibility	Tearing	Tenacity or resistance to tearing
Direct		Thrust or pressure	Squeezing or compression	Resistance to compression	Direct compressibility	Crushing	Resistance to crushing
Indirect	Simple	Shearing or racking stress	Racking or distortion	Rigidity	Lateral pliability	Shearing, sliding, or detrusion	Resistance to shearing
Indirect	Compound	Twisting stress	Torsion or twisting	Resistance to twisting	—	Wrenching	Resistance to Wrenching
Indirect	Compound	Transverse stress	Bending	Transverse stiffness	Flexibility	Breaking across	Resistance to breaking across
	Compound	Indirect thrust	Bending with compression	—	—	Breaking across	Resistance to indirect crushing

FIG. 252.



RACKING OR DISTORTION.

In the diagram (fig. 252) ABCD represents the original form of figure before distortion, and *abcd* represents the distorted form of ABCD.

$$\text{Distortion} = \frac{2(\text{AC} - ac)}{\text{AC}} = \frac{2(bd - \text{BD})}{\text{BD}} \text{ sensibly.}$$

RACKING OR SHEARING STRESS

Is that kind of stress that produces distortion, and the racking stress at the two pairs of faces of a distorted particle is of equal intensity; also every racking stress on a particle is equivalent to the combination of a tension and thrust of the same intensity acting diagonally or at an angle of 45° as regards the stress.

Example (see fig. 252).

R = racking stress in *n* lbs. on the square inch of surface represented by the arrows R.

T = tensile strength in *n* lbs. on the square inch acting parallel to the diagonal BD.

S = compressive strength in *n* lbs. on the square inch acting parallel to the diagonal AC.

$$\text{R} = \text{T} + \text{S}.$$

TO DETERMINE THE MODULUS OF ELASTICITY FROM A RECTANGULAR BEAM SUPPORTED AT BOTH ENDS.

L = length of beam or distance between supports in feet.
W = weight in lbs.
D = depth of beam in inches.
B = breadth of beam in inches.
d = deflection of beam in inches.
E = modulus of elasticity.

$$\text{E} = \frac{\text{WL}^3}{4\text{BD}^3 d} \qquad d = \frac{\text{WL}^3}{4\text{BD}^3\text{E}}$$

MODULUS OF RIGIDITY.

M = modulus of rigidity.
R = racking stress.
D = distortion.

$$\text{M} = \frac{\text{R}}{\text{D}} \qquad \text{R} = \text{MD} \qquad \text{D} = \frac{\text{R}}{\text{M}}$$

FORMULÆ FOR I-SHAPED BEAMS.

S = greatest safe tensile stress.
S' = greatest safe compressive stress.
d = distance of strained flange from neutral axis.
d' = distance of compressed flange from neutral axis.
$D = d + d'$.
A = area of stretched flange.
A' = area of compressed flange.
A'' = area of web from centre to centre of flange.
M = moment of resistance.

When S is greater than S', $A' = \frac{SA}{S'} + \frac{S - S'}{2S'}A''$

Note.—The same unit of measurement to be taken all through.

$$M = D\left\{SA + (2S - S')\frac{A''}{6}\right\} = D\left\{S'A' + (2S' - S)\frac{A''}{6}\right\}$$

When S' is greater than S

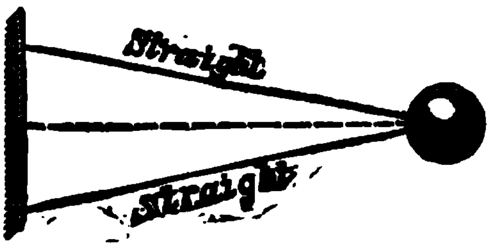
$$A = \frac{S'A'}{S} + \frac{S' - S}{2S}A''$$

$$M = D\left\{S'A' + (2S' - S)\frac{A''}{6}\right\} = D\left\{SA + (S' - 2S)\frac{A'}{6}\right\}$$

TABLE OF BEAMS OF EQUAL STRENGTH THROUGHOUT THEIR LENGTH.

Note.—The sections are in all cases supposed to be rectangular.

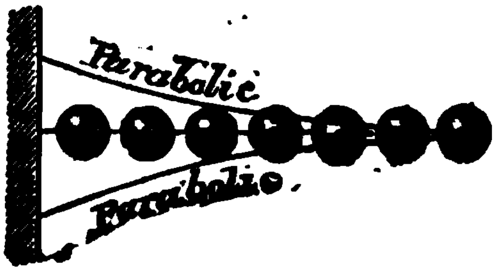
FIG. 253.



Depth equal throughout.

Breadth proportional to distance from loaded end.

FIG. 254.



Depth equal throughout.

Breadth proportional to square of distance from unsupported end.

Table of Beams of Equal Strength throughout their Length (concluded).

Fig. 255.

Breadth equal throughout.

Depth proportional to square root of distance from loaded end.

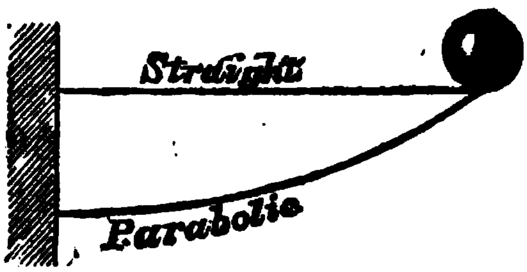


Fig. 256.

Breadth equal throughout.

Depth proportional to distance from unsupported end.

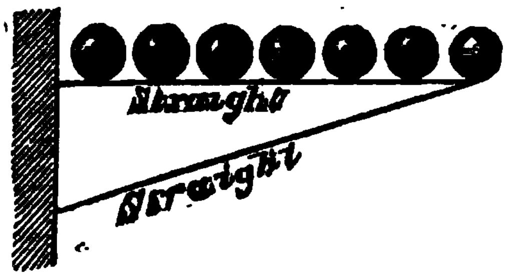


Fig. 257.

Depth equal throughout.

Breadth proportional to distance from nearest point of support.

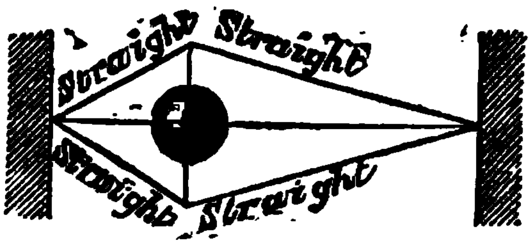


Fig. 258.

Depth equal throughout.

Breadth proportional to product of distance from both points of support.

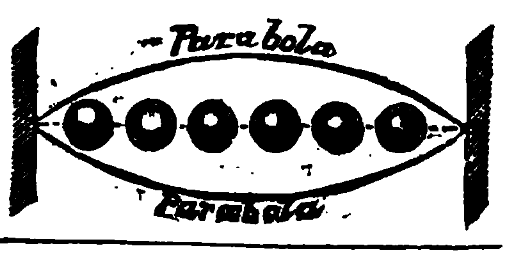


Fig. 259.

Breadth equal throughout.

Depth proportional to the square root of the distance from the nearest point of support.

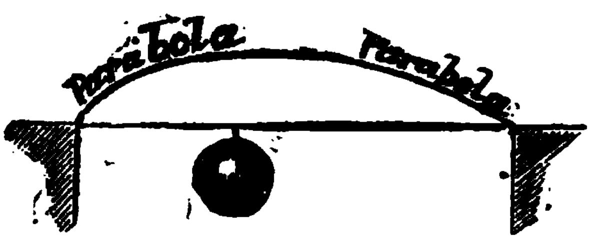
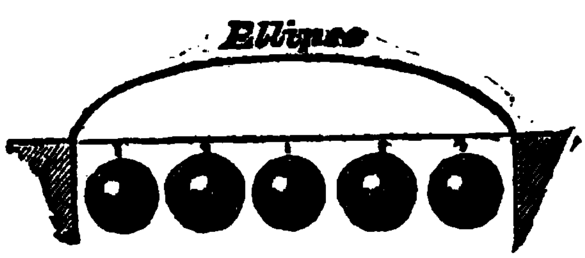


Fig. 260.

Breadth equal throughout.

Depth proportional to the square root of the product of distance from both points of support.



DEFLECTION OF BEAMS.

L = length or span of beam.

I = moment of inertia of greatest cross section (see p. 292).

W = load on beam.

E = modulus of elasticity of material (see pp. 329, 330).

D = deflection. M = bending moment.

r = radius of curvature.

k = coefficient depending on manner of loading and supporting.

$$D = \frac{WL^3k}{EI} \qquad r = \frac{EI}{M} \qquad E = \frac{WL^3k}{DI}$$

VALUES OF k.

Beams Fixed at one End and Loaded at the other.

Uniform cross section	. . . .	$k = \cdot 3333$
„ strength and uniform depth	.	$k = \cdot 5000$
„ „ „ breadth	.	$k = \cdot 6666$

Beams Fixed at one End and Uniformly Loaded.

Uniform cross section	. . . .	$k = \cdot 1250$
„ strength and uniform depth	.	$k = \cdot 2500$
„ „ „ breadth	.	$k = \cdot 5000$

Beams Supported at both Ends and Loaded at the Centre.

Uniform cross section	. . . .	$k = \cdot 0833$
„ strength and uniform depth	.	$k = \cdot 1250$
„ „ „ breadth	.	$k = \cdot 1667$

Beams Supported at both Ends and Uniformly Loaded.

Uniform cross section	. . . .	$k = \cdot 0521$
„ strength and uniform depth	.	$k = \cdot 0625$
„ „ „ breadth	.	$k = \cdot 0713$

TORSIONAL STENGTH OF SHAFTING, OR RESISTANCE TO TWISTING.

P = twisting force in lbs.
r = arm of twisting moment in inches.
M_x = maximum twisting moment in inch-lbs.
M_b = bending moment in inch-lbs.
M_E = equivalent twisting moment when a shaft is simultaneously subjected to a combined bending and twisting moment.
d = outer diameter of shaft or side of square in inches.
d_1 = inner diameter of shaft or side of square in inches.
k = constant depending on shearing stress of material.
R = number of revolutions per minute.
IHP = indicated horse-power transmitted.
E = modulus of elasticity (see pp. 329 and 330).

FOR SLOW-MOVING MACHINERY.

For Circular Sections.

$$M_x = Pr = \frac{\pi d^3 k}{16} = \cdot 19635 d^3 k.$$

$$d = \sqrt[3]{\frac{16 Pr}{\pi k}} = \sqrt[3]{\frac{Pr}{\cdot 196 k}}.$$

For Circular Ring Sections.

$$M_x = Pr = \frac{\pi (d^3 - d_1{}^3) k}{16} = \cdot 19635 (d^3 - d_1{}^3) k.$$

$$d = \sqrt[3]{\frac{Pr + \cdot 196 k d_1{}^3}{\cdot 196 k}}.$$

For Square Sections.

$$M_x = Pr = \frac{2\pi d^3 k}{9} = \cdot 7 d^3 k.$$

$$d = \sqrt[3]{\frac{Pr}{\cdot 7 k}}.$$

Note.—Values of $\frac{\pi d^3}{16}$ may be taken from table on pp. 297 and 298 by halving the numbers for moments of resistance.

FOR QUICK-RUNNING SHAFTING.

Circular Sections.

$$M_x = Pr = \frac{\text{IHP } 63{\cdot}000}{R}.$$

$$d = \sqrt[3]{\frac{\text{IHP} \times 63000 \times 5{\cdot}1}{Rk}} = \sqrt[3]{\frac{\text{IHP}}{R} \times \frac{321300}{k}}.$$

$$M_E = M_b + \sqrt{M_b^2 + M_x^2}.$$

Note.—The maximum twisting moment should always be allowed for. This may be taken in a two-cylinder engine as 1·25 times, and in a single-cylinder engine as 2·0 times the mean twisting moment.

Values of k for Working Load.

Wrought iron	8,000–9,000
Steel from ingots	10,000–12,000
Mild steel scrap	9,000–10,000
Cast iron	7,000–8,000
Gun metal	4,000–5,000
Copper	3,500–4,000

SHORT RULE FOR TORSION OF SHAFTING.

r = radius of arm at which force is applied in inches.
p = force applied in lbs.
d = diameter of shaft for working load in inches.
x = coefficient for material.

$$d = \sqrt{\frac{pr}{x}}.$$

Values of x.

Wrought iron	1,500–1,700
Steel from ingots	1,960–2,350
Mild steel	1,700–1,960
Cast iron	1,372–1,500
Gun metal	750–980
Copper	690–750

STRENGTH OF SHAFTING TO RESIST LATERAL STRESS.

D = diameter of shaft if round, and side if square, in inches.
L = length of shaft supported at both ends in feet.
W = weight applied in lbs.
k = coefficient, depending on form of section and material.

Load applied at middle:—

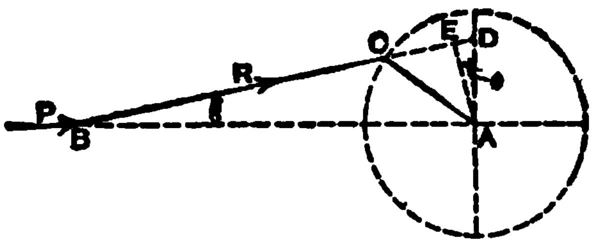
$$D = \sqrt[3]{\frac{LW}{k}}. \qquad L = \frac{D^3 k}{W}.$$

Values of k.

	Round Shaft	Square Shaft
Wood	40	70
Cast iron	500	850
Wrought iron	700	1,200

Twisting Moment of a Crank.

Fig. 261.



Let AB = centre line through cylinder and shaft in inches.
AC = line through centre of crank.
AD = line at right angles to AB.
BC = connecting rod.
CD = line through BC produced.
AE = line perpendicular BD.
P = load on the piston.
R = thrust on connecting rod.
θ = angle ABC = angle EAD.

Twisting moment = R × AE = R × AD cos θ = P × AD.

Coupling Bolts.

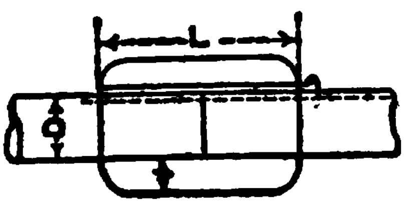
Coupling Bolts are subject to a shearing force only due to the twisting strain on the shaft. If d = diameter of bolts whose number is n, D = diameter of shaft, M_x = twisting moment of shaft, and l = distance from centre of shaft to centre of bolts, k = constant depending on shearing stress,

then $$M_x = n\frac{\pi d^2}{4} \times l \times k, \quad \text{or} \quad d = \sqrt{\frac{M_x}{\cdot 7854 l.k.n.}};$$

but $$M_x = \frac{\pi D^3 k}{16};$$

$$\therefore d = \frac{D}{2}\sqrt{\frac{D}{n \times l}}.$$

Fig. 262.



Box Coupling.

$$L = 3D + 1\tfrac{1}{2}''.$$

$$t = \cdot 45D + \tfrac{1}{4}''.$$

Size of Shaft to Transmit Required Horse-power.

Let IHP = indicated horse-power.
N = number of revolutions per minute.
k = safe stress on material in lbs. per square inch.
D = diameter of shaft in inches.
D_1 = inner diameter for hollow shafting.
M = mean twisting moment in lbs. per square inch = P × R.

$$\text{When IHP} = \frac{2\pi . R \times N \times P}{33000 \times 12}$$

$$\therefore P \times R = \frac{\text{IHP}}{N} \times \frac{33000}{2\pi} = \frac{\text{IHP}}{N} \times 63024 = M.$$

The moment of resistance of a solid circular section $= \cdot 196 D^3 k$.

$$\therefore D = \sqrt[3]{\frac{63024 \times \text{IHP}}{\cdot 196 \times k \times N}} = 68 \cdot 5 \sqrt[3]{\frac{\text{IHP}}{k \times N}}.$$

The moment of resistance of a hollow circular section

$$= \cdot 196 k \frac{D^4 - D_1^4}{D} \text{ when } D_1 = aD; \qquad D = \sqrt[3]{\frac{63024 \times \text{IHP}}{\cdot 196(1-a^4)k \times N}}$$

$$= 68 \cdot 5 \sqrt[3]{\frac{\text{IHP}}{(1-a^4)kN}}.$$

The above expressions are for the mean twisting moment; the maximum twisting moment exceeds the mean as follows:—

Single engine, max. = mean × 1·6.
Two cylinders, cranks at right angles, max. = 1·1 × mean.
Three cylinders, cranks at 120°, max. = 1·05 × mean.

In marine engines the above values must be multiplied again by $\frac{3}{2}$ to give maximum twisting moment.

Values of k for Working Load.

Wrought iron	8,000–9,000
Steel from ingots	10,000–12,000
Mild steel scrap	9,000–10,000
Cast iron	7,000–8,000
Gun metal	4,000–5,000
Copper	3,500–4,000

When Shafts are Subjected to Combined Bending and Torsion.

Let M_x = maximum twisting moment in inch-lbs.
M_b = bending moment in inch-lbs.

Then twisting moment to be substituted in the foregoing expression $= M_b + \sqrt{M_b^2 + M_x^2}$.

THRUST OF ENGINE.

To find the pressure on the thrust block—
Let P = pressure on thrust block,
EHP = effective horse-power = $\frac{2}{3}$ IHP.
S = speed of ship in knots per hour.

Then $\frac{S \times 6080}{60}$ = speed per minute.

Work done in one minute = $P \times S \times \frac{6080}{60}$.

$$\therefore \text{EHP} = P \times S \times \frac{6080}{60 \times 33000} = \tfrac{2}{3}\ \text{IHP};$$

$$\therefore P = \text{IHP} \times \frac{2 \times 60 \times 33000}{S \times 3 \times 6080}$$

$$= \frac{\text{IHP}}{S} \times \frac{4125}{19}$$

$$= \frac{\text{IHP}}{S} \times 217 \text{ nearly.}$$

DIAMETER OF THRUST COLLAR.

Let P = pressure as before.
D = diameter of thrust collars whose number is n.
d = diameter of shaft; pressure allowed per sq. in. = 60 lbs.

$$P = 60\,\frac{\pi}{4}(D^2 - d^2)n = 47(D^2 - d^2)n.$$

$$\therefore D = \sqrt{d^2 + \frac{P}{47n}}.$$

DISTANCE APART OF SHAFT BEARINGS.

D = diameter of shaft in inches.
Load on shaft = m times its weight. Length unsupported = l.

Weight uniformly distributed $l = 10{\cdot}5\sqrt[3]{\frac{D^2}{m+1}}$.

Weight concentrated in the middle $l = 8{\cdot}3\sqrt[3]{\frac{D^2}{m+\frac{1}{2}}}$.

STRENGTH OF RUDDER-HEAD.

P = pressure (normal) on rudder in lbs. when at 35°.
A = immersed area of rudder in square feet.
V = velocity of current parting rudder in feet per second (see page 176).
T = twisting moment on rudder head in inch tons.

M = turning moment of water on rudder = twisting moment of rudder head in foot lbs.

d = distance of centre of effort from axis of rudder in feet.

Note.—For angles at or about 35°, the centre of effort is situated one-eighth of the breadth of the rudder before the centre of gravity of the rudder area (see page 176).

m = moment of resistance of rudder head to twisting in inch tons.

k = coefficient of 5 for cast steel, 4 for wrought iron, and 3 for phosphor bronze.

D = diameter of rudder head in inches.

$$\mathrm{P} = 1{\cdot}12\ \mathrm{AV}^2 \times \sin 35° = {\cdot}642\ \mathrm{AV}^2. \quad \mathrm{M} = \mathrm{P}d.$$

$$\mathrm{T} = \frac{\mathrm{P}d \times 12}{2240} = {\cdot}00344\ d\mathrm{AV}^2 = \frac{d\mathrm{AV}^2}{290}.$$

$$m = \frac{\pi}{16} k\mathrm{D}^3 = {\cdot}196\ k\mathrm{D}^3.$$

$$\mathrm{D} = \sqrt[3]{\frac{\mathrm{T}}{{\cdot}196k}} = {\cdot}26 \sqrt[3]{\frac{\mathrm{AV}^2d}{k}}.$$

If U be the speed of the ship in knots, allowing 10 per cent. slip, $\mathrm{D} = {\cdot}392 \sqrt[3]{\frac{\mathrm{AU}^2d}{k}}$.

Note.—If 40° be the limiting angle of the rudder, instead of 35°, multiply the diameter above obtained by 1·05.

Weights and Test Loads of Anchors.

W = weight in cwts. (exclusive of stock).

T = test load in tons.

L = length of anchor in feet.

A = area of augmented surface in square feet.

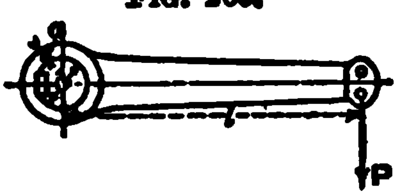
w = weight of stock in cwts.

$$\mathrm{T} = \frac{\mathrm{A}}{800} \qquad \mathrm{W} = \frac{\mathrm{L}^3}{50} \qquad w = \frac{\mathrm{W}}{5}$$

$$\mathrm{L} = \sqrt[3]{50\mathrm{W}}$$

Strength of Tiller (Fig. 263).

Fig. 263.



Let P = force acting square to tiller.

d = diameter of rudder head.

a = thickness of boss, and h = its depth.

Then the rudder is turned by means of the force communicated to the key.

Turning moment of tiller $= P \times l =$ moment of force S on key about centre of rudder head $= S \times \frac{d}{2}$.

$$\therefore P \times l = S \times \frac{d}{2}; \quad \therefore S = 2P \times \frac{l}{d}.$$

If $R =$ strain on cross section of boss,

$$R \times \frac{d+a}{2} = P \times l; \ \therefore R = 2P \times \frac{l}{d+a}.$$

Example.—To find the section of a wrought-iron tiller when the force on end of tiller $= 10$ tons, length of tiller 14′ 0″, diameter of rudder head 16″, $\frac{h}{a} = 2{\cdot}5$, safe stress for iron $= 4$ tons per square inch.

Let $a = \frac{10}{2{\cdot}5} = 4$ inches;

$$\text{then } R = 2 \times 10 \times \frac{14 \times 12}{16 + 4} = \frac{2 \times 10 \times 14 \times 12}{20} = 168 \text{ tons.}$$

$$\text{Area of cross section} = \frac{168}{4} = 42'', \text{ and the depth} = 10'';$$

$$\therefore \text{breadth} = \frac{42}{10} = 4{\cdot}2 \text{ inches.}$$

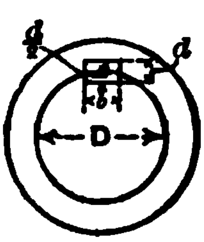
In practice h varies from d to $\cdot 9d$, and a varies from $\cdot 3d$ to $\cdot 35d$.

Keys and Keyways (Fig. 264).

Let $D =$ diameter of shaft, $b =$ breadth, and $d =$ depth of key.

$b = \frac{1}{4}D + \frac{1}{8}''$, except when D is more than 11″; and then $b = \frac{1}{4}D + \frac{1}{4}''$.

Fig. 264.



When D is 9″ or less, $d = \frac{1}{8}D + \frac{1}{8}''$.

When D is more than 9″, $d = \frac{1}{8}D$.

PROPORTIONS OF KEYS FOR WHEELS, ETC.

Diameter of Shaft	Size of Key		Depth sunk in Shaft	Depth sunk in Wheel	Diameter of Shaft	Size of Key		Depth sunk in Shaft	Depth sunk in Wheel
	Breadth	Thickness				Breadth	Thickness		
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{3}{32}$	$\frac{5}{32}$	$5\frac{3}{4}$	$1\frac{9}{16}$	$\frac{13}{16}$	$\frac{9}{32}$	$\frac{17}{32}$
$1\frac{1}{4}$	$\frac{7}{16}$	$\frac{9}{32}$	$\frac{3}{32}$	$\frac{3}{16}$	6	$1\frac{5}{8}$	$\frac{7}{8}$	$\frac{9}{32}$	$\frac{19}{32}$
$1\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{16}$	$\frac{3}{32}$	$\frac{7}{32}$	$6\frac{1}{4}$	$1\frac{11}{16}$	$\frac{7}{8}$	$\frac{9}{32}$	$\frac{19}{32}$
$1\frac{3}{4}$	$\frac{9}{16}$	$\frac{11}{32}$	$\frac{1}{8}$	$\frac{7}{32}$	$6\frac{1}{2}$	$1\frac{3}{4}$	$\frac{15}{16}$	$\frac{5}{16}$	$\frac{5}{8}$
2	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{1}{8}$	$\frac{1}{4}$	$6\frac{3}{4}$	$1\frac{13}{16}$	$\frac{15}{16}$	$\frac{5}{16}$	$\frac{5}{8}$
$2\frac{1}{4}$	$\frac{11}{16}$	$\frac{13}{32}$	$\frac{5}{32}$	$\frac{1}{4}$	7	$1\frac{7}{8}$	1	$\frac{5}{16}$	$\frac{11}{16}$
$2\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{5}{32}$	$\frac{9}{32}$	$7\frac{1}{4}$	$1\frac{15}{16}$	1	$\frac{5}{16}$	$\frac{11}{16}$
$2\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{16}$	$\frac{5}{32}$	$\frac{9}{32}$	$7\frac{1}{2}$	2	$1\frac{1}{16}$	$\frac{5}{16}$	$\frac{3}{4}$
3	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{5}{16}$	$7\frac{3}{4}$	$2\frac{1}{16}$	$1\frac{1}{16}$	$\frac{5}{16}$	$\frac{3}{4}$
$3\frac{1}{4}$	$\frac{15}{16}$	$\frac{1}{2}$	$\frac{3}{16}$	$\frac{5}{16}$	8	$2\frac{1}{8}$	$1\frac{1}{8}$	$\frac{3}{8}$	$\frac{3}{4}$
$3\frac{1}{2}$	1	$\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	$8\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{8}$	$\frac{3}{4}$
$3\frac{3}{4}$	$1\frac{1}{16}$	$\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	9	$2\frac{3}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
4	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{7}{32}$	$\frac{13}{32}$	$9\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
$4\frac{1}{4}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{7}{32}$	$\frac{13}{32}$	10	$2\frac{5}{8}$	$1\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
$4\frac{1}{2}$	$1\frac{1}{4}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{7}{16}$	$10\frac{1}{2}$	$2\frac{3}{4}$	$1\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{8}$
$4\frac{3}{4}$	$1\frac{5}{16}$	$\frac{11}{16}$	$\frac{1}{4}$	$\frac{7}{16}$	11	3	$1\frac{3}{8}$	$\frac{1}{2}$	$\frac{7}{8}$
5	$1\frac{3}{8}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	$11\frac{1}{2}$	$3\frac{1}{8}$	$1\frac{1}{2}$	$\frac{1}{2}$	1
$5\frac{1}{4}$	$1\frac{7}{16}$	$\frac{3}{4}$	$\frac{1}{4}$	$\frac{1}{2}$	12	$3\frac{1}{4}$	$1\frac{1}{2}$	$\frac{1}{2}$	1
$5\frac{1}{2}$	$1\frac{1}{2}$	$\frac{13}{16}$	$\frac{9}{32}$	$\frac{17}{32}$	—	—	—	—	—

Note.—The depth sunk in the shaft or wheel is measured at the side of the key. When keys are made with gib-heads, the depth and length of the gib-head should each be equal to the thickness of the key. Taper of keys $\frac{3}{16}$ inch per foot in length.

EFFECT OF DEPTH UPON THE STRENGTH OF A GIRDER.

(BY F. PURVIS, M.I.N.A.)

From *Transactions of the Institution of Naval Architects*, 1878.

Suppose the depth of the girder is increased by adding material to the upper part only.

Let h = distance of upper part from neutral axis originally.

y = distance of upper part from neutral axis after adding weight.

A = weight of girder originally; a = weight added.

I = original moment of inertia of section.

p and p_1 = strains on upper part before and after weight is added.

M = greatest bending moment, which is the same in each case.

Before weight is added $\frac{p}{M} = \frac{h}{I}$.

When weight a is added, C.G. is raised $\frac{ay}{A+a}$.

The increase in the moment of inertia being

$$ay^2 - (A+a)\frac{a^2y^2}{(A+a)^2},$$

$$\text{so that } \frac{p_1}{M} = \frac{y - \frac{ay}{A+a}}{I + ay^2 - (A+a)\frac{a^2y^2}{(A+a)^2}}.$$

$$\therefore \frac{p_1}{p} = \frac{\frac{y}{h}\left(1 - \frac{a}{A+a}\right)}{1 + \left\{\frac{a}{I} - \frac{a^2}{I(A+a)}\right\}y^2}$$

which gives the relation between p_1 and p.

PROPORTIONS OF CHAIN-CABLE LINKS.

Length outside . . .	=	6	diameters of bolt.
„ inside . . .	=	4	„ „
Breadth outside . . .	=	3·6	„ „
Thickness of stud at end .	=	1	„ „
„ „ middle	=	$\frac{3}{5}$	„ „

DESCRIPTION OF CABLES.

Hemp is laid up *right-handed* into yarns.
Yarns are laid up *left-handed* into strands.
Three strands laid up *right-handed* make a hawser.
Three hawsers laid up *left-handed* make a cable.
Shroud-laid rope has a *core* surrounded by four strands.

PUNCHING IRON PLATES.

P = pressure in tons to punch a plate.
W = work in foot lbs. to punch a plate.
r = radius of punch in inches.
t = thickness of plate in inches.

$$P = 114rt$$
$$W = 10640rt^2$$

PENETRATION OF SHOT INTO IRON ARMOUR.

d = distance of penetration in inches.
w = weight of shot in lbs.
v = velocity of shot in feet per second at time of impact.
r = radius of shot in inches.

$d = \sqrt{\frac{wv^2}{3374940r}}$ for round-ended cast iron service shot.

$d = \sqrt{\frac{wv^2}{1571360r}}$ for flat-ended steel shot.

VELOCITY OF SHOT.

W = weight of shot in lbs.
w = weight of charge in lbs.
V = initial velocity of shot in feet per second.
v = velocity of shot at n feet per second.
r = radius of shot in inches.

$$V = \frac{2800\sqrt{w}}{\sqrt{W}} \qquad v = \frac{V}{1 + \left(\cdot 000063\frac{r^2}{W}\right)Vn}.$$

IMPACT OF SHOT.

W = weight of shot in lbs.
V = velocity of shot at time of impact in feet per second.
I = force of impact in foot lbs. per second.

$$I = \frac{WV^2}{2g} = \frac{WV^2}{64\cdot 4} = \cdot 01553WV^2.$$

TO DETERMINE THE SIZE OF THE RIM OF A FLY-WHEEL.

v = velocity in feet per second at the periphery.
n = number of revolutions per minute.
d = diameter of wheel in feet.
w = weight per foot of rim.
a = sectional area of rim in square inches.
c = centrifugal force for one foot of rim.
s = strain on any section of rim.

$$c = \frac{wv^2}{16\cdot 1d} \qquad s = \frac{cd}{2} = \frac{wv^2}{32\cdot 2}$$

$$a = \frac{wv^2}{57900} = \frac{w}{3\cdot 2} \qquad v = \frac{nd}{19}$$

$$n = \frac{2546}{d} \text{ for cast iron.}$$

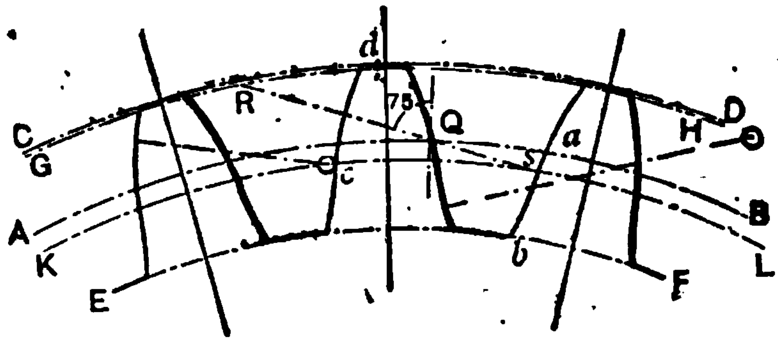
$$n = \frac{4427}{d} \text{ for wrought iron.}$$

TOOTHED-WHEEL GEARING.

Easy Method of Setting Out the Teeth. (Fig. 265).

Let AB be the pitch circle. From the same centre draw circles CD, EF, so that their distances from the pitch circle are

FIG. 265.

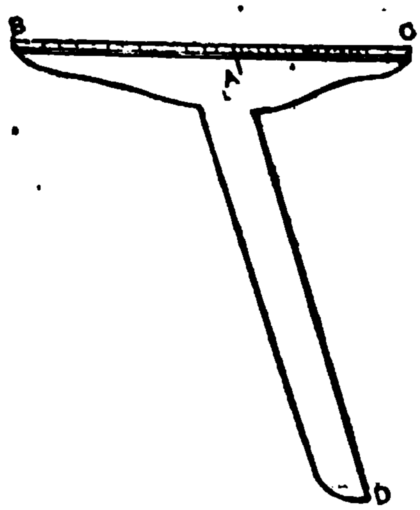


respectively ·35 P and ·45 P (P being the pitch). The points of the teeth will end on CD, and the roots on EF.

Round the pitch circle AB, set off the pitch and the edges of the teeth, making the thickness of each tooth ·45 P.

Through the edge Q of one of the teeth draw RQS inclined at an angle of 75° to the radius through Q. Make RQ equal to ·95 P and QS ·55 P; and through R and S draw circles GH, EF. From R as centre strike in the curve *ab* for the lower half of the tooth, and keeping this radius constant and the centres always

FIG. 266.



on the circle GH, draw the lower half of each tooth in turn. Then from centre S strike in the curve *od* for the upper half, and keeping the centres on KL, and the same radius, draw in

the upper half of each tooth. The complete shape of each tooth is now drawn in.

In order to draw the line RQS, the instrument shown in fig. 266 is often used.

The parts BC and AD are inclined at 75°, and from A two scales are set off along AB and AC, so that QR and QS may be at once measured when the pitch is given in inches.

Strength of Wheel-gearing when the Width of Teeth is not taken into Account (Fig. 266).—At one part of the motion the pressure is acting at the point of a tooth, and if the tooth is uneven it may act at one corner only. Considering the tooth to act as a cantilever—

Let P = whole pressure of one wheel on the other.

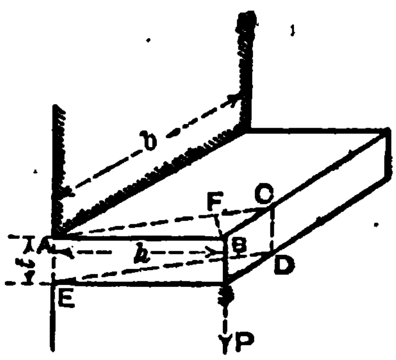
n = number of teeth, h = height of tooth, and t = mean thickness of tooth.

HP = horse-power transmitted.

N = revolutions of wheel per minute, and R = radius of wheel in inches.

p = pitch of teeth.

FIG. 267.



V = velocity of pitch line in feet per minute.

f = safe load on material in lbs. per square inch.

Angle CAB = θ,

$$V = \frac{2\pi RN}{12} = \frac{p \times n \times N}{12},$$

$$P = \frac{33000 HP}{V} = \frac{33000 \times HP \times 12}{p \times n \times N} = \frac{396000 \times HP}{p \times n \times N}.$$

The tooth tends to break across a line AC (see fig. 267).

$$\text{AC} = \text{AB} \sec \text{CAB} = h \sec \theta,$$

$$\text{BF} = \text{AB} \sin \text{CAB} = h \sin \theta.$$

The bending moment at $\text{AC} = \text{P} \times h \sin \theta$,

and the moment of resistance $= \frac{1}{6} fht^2 \sec \theta$.

$$\text{P} \times h \sin \theta = \frac{1}{6} fht^2 \sec \theta. \qquad \therefore f = \frac{3\text{P}}{t^2} \sin 2\theta,$$

which will be a maximum when $\sin 2\theta = 1$, and $\therefore \theta = 45°$;

$$\text{then } f = \frac{3\text{P}}{t^2}, \ \text{P} = \tfrac{1}{3} ft^2, \ t = \sqrt{\frac{3\text{P}}{f}}.$$

In the above formula P has been supposed to act on one tooth only, but in any gearing there should always be two teeth in contact on each wheel, so that we may take the force acting on one tooth $= \frac{2}{3}$ P,

$$\text{then } t = \sqrt{\frac{2\text{P}}{f}}.$$

In properly constructed gearing the force will never be concentrated on one point. If the pressure is distributed along the edge of the tooth, using the above notation.

The bending moment at root of tooth $= \text{P}h$.

Moment of resistance $= \frac{1}{6} fbt^2$;

$$\therefore \text{P} = \frac{1}{6} \frac{fbt^2}{h}.$$

The pressure acting on one tooth may be taken $= \frac{2}{3}$P as before,

$$\therefore \text{P} = \frac{fbt^2}{9h}.$$

Relation of Horse-power Transmitted and Velocity at the Pitch Circle to Pressure of Teeth.

Number of Horses' Power Transmitted	Velocity in Feet per Second									
	1 ft.	3 ft.	5 ft.	7 ft.	9 ft.	11 ft.	13 ft.	15 ft.	20 ft.	25 ft.
H.P.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1	550	183	110	79	61	50	42	37	28	22
2	1,100	367	220	157	122	100	85	73	55	44
3	1,650	550	330	236	183	150	127	110	83	66
4	2,200	733	440	314	224	200	169	146	110	88
5	2,750	917	550	393	306	250	212	183	138	110
10	5,500	1,833	1,100	786	611	500	423	367	275	220
15	8,250	2,750	1,650	1,179	917	750	635	550	413	330
20	11,000	3,667	2,200	1,571	1,222	1,000	846	733	550	440
25	13,750	4,583	2,750	1,964	1,527	1,250	1,058	917	688	550
30	16,500	5,500	3,300	2,357	1,833	1,500	1,269	1,100	825	660
40	22,000	7,333	4,400	3,143	2,444	2,000	1,692	1,467	1,100	880
50	27,500	9,167	5,500	3,928	3,055	2,500	2,115	1,833	1,375	1,100
60	33,000	11,000	6,600	4,714	3,667	3,000	2,538	2,200	1,650	1,320
70	38,500	12,833	7,700	5,500	4,278	3,500	2,962	2,567	1,925	1,540
80	44,000	14,667	8,800	6,285	4,889	4,000	3,385	2,933	2,200	1,760
90	49,500	16,500	9,900	7,071	5,500	4,500	3,808	3,308	2,475	1,980
100	55,000	18,333	11,000	7,857	6,111	5,000	4,231	3,667	2,750	2,200
110	60,500	20,167	12,100	8,643	6,722	5,500	4,654	4,033	3,025	2,420
120	66,000	22,000	13,200	9,423	7,333	6,000	5,077	4,400	3,300	2,640
130	71,500	23,833	14,300	10,214	7,944	6,500	5,500	4,767	3,575	2,860
140	—	25,667	15,400	11,000	8,556	7,000	5,923	5,133	3,850	3,080
150	—	27,500	16,500	11,786	9,167	7,500	6,346	5,500	4,125	3,300
160	—	29,333	17,600	12,571	9,778	8,000	6,769	5,867	4,400	3,520
170	—	31,167	18,700	13,357	10,389	8,500	7,192	6,233	4,675	3,740
180	—	—	19,800	14,143	11,000	9,000	7,615	6,600	4,950	3,960
190	—	—	20,900	14,929	11,611	9,500	8,038	6,967	5,225	4,180
200	—	—	22,000	15,714	12,222	10,000	8,462	7,333	5,500	4,400
300	—	—	33,000	23,571	18,333	15,000	12,692	7,700	8,250	6,600
400	—	—	44,000	31,428	24,444	20,000	16,923	8,067	11,000	8,800
500	—	—	55,000	39,285	30,555	25,000	21,154	8,433	13,750	11,000

TABLE SHOWING THE PITCH AND THICKNESS OF TEETH TO TRANSMIT A GIVEN NUMBER OF HORSES' POWER AT DIFFERENT VELOCITIES.

Pitch in Inches	Thickness of Teeth in Inches	Velocity at Pitch Line in Feet per Second												
		1	3	5	7	9	11	13	15	20	25	30	40	50
		H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.	H.P.
½	·22	·14	·42	·71	·99	1·26	1·5	1·8	2·1	2·8	3·5	4·2	5·6	7·1
¾	·33	·32	·95	1·59	2·22	2·75	3·5	4·1	4·7	6·3	7·9	9·5	12·7	15·9
1	·45	·59	1·77	2·95	4·12	5·31	6·5	7·7	8·8	11·8	14·7	17·7	23·6	29·5
1¼	·56	·91	2·74	4·56	6·38	8·22	10·0	11·9	13·7	18·2	22·8	27·4	36·5	45·6
1½	·68	1·34	4·03	6·72	9·41	12·09	14·8	17·5	20·2	26·9	33·6	40·3	53·7	67·2
1¾	·80	1·86	5·58	9·31	13·03	16·74	20·5	24·2	27·9	37·2	46·5	55·8	74·4	93·1
2	·92	2·46	7·38	12·31	17·23	22·14	27·1	32·0	36·9	49·2	61·5	73·8	98·4	123·1
2¼	1·04	3·14	9·43	15·72	22·01	27·29	34·6	40·9	47·2	62·9	78·6	94·3	125·7	157·2
2½	1·15	3·85	11·54	19·23	26·92	34·62	42·3	50·0	57·7	76·9	96·1	115·4	153·8	192·3
2¾	1·27	4·69	14·07	23·45	32·82	42·21	51·6	61·0	70·3	93·8	117·2	140·6	187·5	234·5
3	1·39	5·62	16·84	28·08	39·31	50·42	61·8	73·0	84·2	112·3	140·4	168·5	224·6	280·8
3¼	1·51	6·63	19·88	33·14	46·40	59·64	72·9	86·2	99·4	132·6	165·7	198·8	265·1	331·4
3½	1·62	7·63	22·89	38·15	53·40	68·67	83·9	99·2	114·4	152·6	190·7	228·9	305·1	381·5
3¾	1·74	8·80	26·40	44·00	61·61	79·20	96·8	114·4	132·0	176·0	220·0	264·0	352·0	440·0
4	1·86	10·06	30·17	50·29	70·40	90·50	110·6	130·7	150·8	201·1	251·4	301·7	402·3	502·9
4½	2·09	12·70	38·09	63·49	88·89	114·27	139·7	165·1	190·5	254·0	317·5	380·9	507·9	634·9
5	2·33	15·78	47·35	78·91	110·47	142·05	173·6	205·2	236·7	315·6	394·5	473·5	631·3	789·1
5½	2·56	19·05	57·15	95·26	133·36	171·45	209·6	267·7	285·8	381·0	476·3	571·5	762·0	952·6
6	2·80	22·79	68·37	113·96	159·54	205·11	250·7	316·3	341·9	455·8	569·7	683·7	911·6	1139·6

TABLE SHOWING BREADTH OF TEETH REQUIRED TO TRANSMIT DIFFERENT AMOUNTS OF FORCE AT A UNIFORM PRESSURE OF 400 LBS. PER INCH.

Number of Horses' Power Transmitted	Velocity of Pitch Line in Feet per Second										
	1	3	5	7	9	11	13	15	20	25	30
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
1	1·4	0·5	0·3	0·2	0·15	0·12	0·11	0·09	0·07	0·05	0·05
2	2·7	0·9	0·6	0·4	0·3	0·25	0·21	0·18	0·14	0·11	0·09
3	4·1	1·4	0·8	0·6	0·5	0·38	0·32	0·27	0·21	0·17	0·14
4	5·5	1·8	1·1	0·8	0·6	0·50	0·42	0·37	0·28	0·22	0·18
5	6·9	2·3	1·4	1·0	0·8	0·62	0·53	0·46	0·35	0·28	0·23
10	13·7	4·6	2·7	2·0	1·5	1·3	1·06	0·92	0·69	0·55	0·46
15	20·6	6·9	4·1	2·9	2·3	1·9	1·6	1·37	1·03	0·83	0·69
20	34·2	9·2	5·5	3·9	3·1	2·5	2·1	1·83	1·38	1·10	0·92
25	41·2	11·4	6·9	4·9	3·8	3·1	2·6	2·3	1·72	1·38	1·14
30	55·0	13·8	8·2	5·9	4·6	3·8	3·2	2·8	2·06	1·65	1·38
40	68·8	18·3	11·0	7·9	6·1	5·0	4·2	3·7	2·75	2·20	1·83
50	82·5	22·9	13·7	9·8	7·6	6·3	5·3	4·6	3·44	2·75	2·29
60	96·2	27·5	16·5	11·8	9·1	7·5	6·4	5·5	4·1	3·30	2·75
70	110·0	32·1	19·2	13·8	10·7	8·8	7·4	6·4	4·8	3·85	3·21
80	123·8	36·7	22·0	15·7	12·2	10·0	8·5	7·3	5·5	4·40	3·67
90	137·5	41·2	24·8	17·7	13·8	11·2	9·5	8·2	6·2	4·95	4·12
100	151·2	45·8	27·5	19·6	15·3	12·5	10·6	9·1	6·9	5·50	4·58
110	165·0	50·4	30·3	21·6	16·8	13·7	11·6	10·1	7·5	6·05	5·04
120	178·8	55·0	33·0	23·5	18·3	15·0	12·7	11·0	8·3	6·6	5·50
130	—	59·8	35·7	25·5	19·8	16·3	13·8	11·9	8·9	7·2	5·98
140	—	64·2	38·5	27·5	21·1	17·5	14·8	12·8	9·6	7·7	6·42
150	—	68·7	41·3	29·4	22·9	18·7	15·8	13·7	10·3	8·2	6·87
160	—	73·3	44·0	31·4	24·5	20·0	16·9	14·6	11·0	8·8	7·33

Table showing the Relation of Pitch, Diameter, and Number of Teeth.

No. of Teeth in Wheel	Pitch in Inches ½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3¼	3½	4	4½	5
For each Tooth add	·1591	·2386	·3182	·3978	·4774	·5570	·6366	·7135	·7958	·8754	·9548	1·035	1·114	1·273	1·427	1·592
12	1·91	2·86	3·82	4·77	5·73	6·68	7·64	8·56	9·55	10·50	11·46	12·41	13·37	15·28	17·12	19·10
13	2·07	3·10	4·14	5·17	6·21	7·24	8·28	9·28	10·35	11·38	12·41	13·45	14·48	16·55	18·55	20·69
14	2·23	3·34	4·46	5·57	6·68	7·80	8·91	9·99	11·14	12·26	13·37	14·48	15·60	17·83	19·98	22·28
15	2·39	3·58	4·77	5·97	7·16	8·36	9·55	10·70	11·94	13·13	14·32	15·52	16·71	19·10	21·41	23·87
16	2·55	3·82	5·09	6·37	7·64	8·91	10·19	11·41	12·73	14·01	15·28	16·55	17·83	20·37	22·83	25·46
17	2·70	4·06	5·41	6·77	8·12	9·47	10·82	12·13	13·53	14·88	16·23	17·59	18·94	21·64	24·26	27·06
18	2·86	4·30	5·73	7·17	8·60	10·03	11·46	12·84	14·32	15·76	17·19	18·62	20·05	22·92	25·69	28·65
19	3·02	4·54	6·05	7·56	9·08	10·58	12·10	13·56	15·12	16·63	18·14	19·66	21·17	24·19	27·11	30·24
20	3·18	4·77	6·36	7·96	9·55	11·14	12·73	14·27	15·92	17·51	19·10	20·69	22·28	25·46	28·54	31·83
21	3·34	5·01	6·68	8·36	10·02	11·70	13·37	14·98	16·71	18·38	20·05	21·72	23·40	26·74	29·97	33·42
22	3·50	5·25	7·00	8·76	10·50	12·25	14·01	15·70	17·51	19·26	21·01	22·76	24·51	28·01	31·39	35·01
23	3·66	5·49	7·32	9·16	10·98	12·81	14·64	16·41	18·30	20·13	21·96	23·79	25·62	29·28	32·82	36·60
24	3·82	5·73	7·64	9·55	11·46	13·37	15·28	17·12	19·10	21·01	22·92	24·83	26·74	30·56	34·25	38·20
25	3·97	5·97	7·96	9·96	11·94	13·93	15·92	17·84	19·90	21·89	23·87	25·86	27·85	31·84	35·68	39·79
30	4·77	7·16	9·55	11·93	14·32	16·71	19·10	21·41	23·87	26·26	28·64	31·04	33·42	38·21	42·81	47·74

35	5·57	8·35	11·14	13·92	16·71	19·50	22·28	24·97	27·85	30·64	33·42	36·21	38·99	44·57	49·95	55·70
40	6·36	9·54	12·73	15·91	19·10	22·28	25·46	28·54	31·83	35·02	38·19	41·38	44·56	50·94	57·08	63·66
45	7·16	10·74	14·32	17·90	21·49	25·07	28·65	32·11	35·81	39·39	42·97	46·55	50·13	57·30	64·22	71·62
50	7·96	11·93	15·91	19·89	23·87	27·85	31·83	35·67	39·79	43·77	47·74	51·73	55·71	63·67	71·35	79·58
55	8·75	13·12	17·50	21·88	26·26	30·64	35·01	39·24	43·77	48·15	52·51	56·90	61·28	70·04	78·49	87·53
60	9·55	14·32	19·09	23·87	28·64	33·42	38·20	42·81	47·75	52·52	57·29	62·07	66·85	76·40	85·62	95·49
65	10·34	15·51	20·68	25·86	31·03	36·21	41·38	46·38	51·72	56·90	62·06	67·24	72·42	82·77	92·76	103·45
70	11·14	16·70	22·27	27·85	33·42	38·99	44·56	49·94	55·71	61·28	66·84	72·42	77·99	89·13	99·89	111·41
75	11·93	17·89	23·86	29·84	35·81	41·78	47·75	53·51	59·69	65·66	71·61	77·59	83·56	95·50	107·03	119·36
80	12·73	19·09	25·46	31·82	38·19	44·56	50·93	57·08	63·66	70·03	76·38	82·76	89·13	101·87	114·16	127·32
85	13·52	20·28	27·05	33·81	40·58	47·35	54·11	60·65	67·64	74·41	81·16	87·93	94·70	108·23	121·30	135·28
90	14·32	21·47	28·64	35·80	42·97	50·13	57·29	64·21	71·62	78·78	85·93	93·11	100·27	114·60	128·43	143·23
95	15·11	22·66	30·23	37·79	45·36	52·91	60·47	67·78	75·60	83·16	90·70	98·28	105·84	120·96	135·57	151·19
100	15·91	23·86	31·82	39·78	47·74	55·70	63·66	71·35	79·58	87·54	95·48	103·45	111·41	127·32	142·70	159·15
110	17·50	26·24	35·00	43·76	52·51	61·27	70·03	78·48	87·54	96·29	105·03	113·80	122·55	140·05	156·97	175·07
120	19·09	28·63	38·18	47·74	57·28	66·84	76·39	85·62	95·50	105·05	114·58	124·14	133·69	152·78	171·24	190·98
130	20·68	31·02	41·36	51·72	62·06	72·41	82·76	92·75	103·45	113·80	124·12	134·50	144·83	165·52	185·51	206·90
140	22·27	33·40	44·54	55·70	66·84	77·98	89·12	99·89	111·41	122·56	133·67	144·83	155·97	178·25	199·78	222·81
150	23·86	35·79	47·73	59·67	71·61	83·55	95·49	107·03	119·37	131·31	143·22	155·18	167·12	190·98	214·05	238·73
160	25·45	38·18	50·91	63·65	76·38	89·12	101·86	114·16	127·33	140·06	152·77	165·52	178·26	203·71	228·32	254·64
170	27·04	40·56	54·10	67·63	81·16	94·69	108·22	121·29	135·29	148·82	162·32	175·87	189·40	216·44	242·59	270·56
180	28·64	42·95	57·28	71·60	85·93	100·26	114·59	128·43	143·24	157·57	171·86	186·21	200·54	229·18	256·86	286·47
190	30·23	45·33	60·46	75·58	90·71	105·83	120·95	135·57	151·20	166·33	181·41	196·56	211·68	241·91	271·13	302·39
200	31·82	47·72	63·64	79·56	95·48	111·40	127·32	142·70	159·16	175·08	190·96	206·90	222·82	254·64	285·40	318·30

HAND CRANES.

P = power applied to handle in lbs.
D = diameter of circle described by handle in inches.
W = weight to be lifted in lbs.
N = number of revolutions of handle.
n = number of revolutions of barrel.
d = diameter of barrel in inches.
l = length of handle in inches.

$$d=\frac{\mathrm{DPN}}{n\mathrm{W}} \qquad \frac{\mathrm{N}}{n}=\frac{\mathrm{W}d}{\mathrm{DP}} \qquad \mathrm{D}=\frac{\mathrm{W}dn}{\mathrm{PN}} \qquad \mathrm{W}=\frac{\mathrm{DPN}}{dn}$$

$$\mathrm{P}=\frac{\mathrm{W}dn}{\mathrm{DN}} \qquad l=\frac{\mathrm{W}dn}{2\mathrm{PN}} \qquad n=\frac{2\mathrm{PN}l}{\mathrm{W}d}$$

Note.—The ordinary height of handle above ground is 36 inches. Diameter of circle described by handle, 32 inches. Power imparted by one man, from 15 to 20 lbs.

STEAM CRANES.

S = speed of piston in feet per minute.
D = diameter of main drum in feet.
W = load to be lifted.
N = number of revolutions of main drum per minute.
P = pressure on one piston.
s = speed of main drum in feet.
n = number of revolutions of crank shaft per minute.
l = length of stroke in feet.
d = diameter of piston in inches.
p = pressure of steam in lbs. per square inch.

$$\mathrm{S}=2nl \qquad s=3{\cdot}1416\mathrm{ND} \qquad \mathrm{P}={\cdot}7854pd^2$$

$$\mathrm{W}=\frac{nlpd^2}{\mathrm{ND}}$$

VELOCITY OF PULLEYS.

V = velocity of driving pulley.
D = diameter of driving pulley.
v = velocity of driven pulley.
d = diameter of driven pulley

$$\mathrm{D}=\frac{vd}{\mathrm{V}} \qquad d=\frac{\mathrm{DV}}{v} \qquad \mathrm{V}=\frac{dv}{\mathrm{D}} \qquad v=\frac{\mathrm{DV}}{d}$$

The final velocity of any number of pulleys

$=\dfrac{\mathrm{V}\times\mathrm{D}\times\mathrm{D}'\times\mathrm{D}''\ \&c.,}{d\times d'\times d''\ \&c.,}$ where D, D′, D″, &c., are the diameters of the driving wheels or pulleys, and d, d', d'', &c., the diameters of the driven pulleys.

TABLE OF THE WEIGHT AND STRENGTH OF MATERIALS.

METALS.

Name	Specific Gravity	Lbs. in a Cubic Foot	Tearing Force Lbs. on Sq. In.	Crushing Force Lbs. on Sq. In.	Modulus of Elasticity Lbs. on Sq. In.
Aluminium, cast	2·560	160·0	—	—	—
„ sheet	2·670	166·9	—	—	—
Antimony, cast	6·702	418·9	1,053	—	—
Arsenic	5·763	360·2	-	—	—
Bismuth, cast	9·822	613·9	2,798	—	—
Brass, cast	8·396	524·8	18,000	10,300	9,170,000
„ sheet	8·525	532·8	31,360	—	—
„ wire	8·544	538·0	49,000	—	14 230,000
Bronze	8·222	513·4	—	—	—
Cobalt, cast	7·811	488·2	—	—	—
Copper, bolts	8·850	551·8	36,000	—	—
„ cast	8·607	537·9	19,000	—	—
„ sheet	8·785	549·1	30,000	—	—
„ wire	8·878	548·6	60,000	—	—
Gold, pure	19·258	1203 6	20,400	—	—
„ hammered	19·362	1210·1	—	—	—
„ standard	17·647	1102·9	—	—	—
Gun metal	8·153	509·6	36,000	—	9,873,000
Iron, cast, from	6·955	434·7	[illegible]00	82,000	14,000,000
„ „ to	7·295	455·9	[illegible]00	145,000	22,900,000
„ „ average	7·125	445·3	[illegible]00	112,000	17,000,000
„ wrought, from	7·560	472·5	[illegible]00	40,800	—
„ „ to	7·[illegible]	[illegible]	[illegible]00	32,000	—
„ „ average	7·680	480·0	[illegible]00	36,000	26,000,000
Lead, cast	11·352	709·5	[illegible]92	6,000	—
„ sheet	11 400	712·8	3,328	—	720,000
Mercury, fluid	13·568	848·0	—	—	—
„ solid	15·632	977·0	—	—	—
Muntz's metal	8·200	511·0	49,000	—	—
Nickel, cast	7·807	487·9	—	—	—
Pewter	11·600	702·5	—	—	—
Phosphor bronze	8·600	536·8	58,000	—	—
Platinum, pure	19·500	1218·8	—	—	—
„ sheet	20·337	1271·0	265,000	—	24,240,000
Silver, pure	10·474	[illegible]	42,000	—	—
„ standard	10·534	658·4	—	—	—
Steel, cast	7·829	489·3	58,240 to 67,000	—	—
Steel, hard	7·818	488·6	103,000	—	42,000,000
„ soft	7·834	489·6	121,700	—	29,000,000
Tin, cast	7·291	455·7	4,600	14,600	4,550,000
Type metal	10·450	653·1	—	—	—
Zinc, cast	7·028	439·3	3,500	—	13,500,000
„ sheet	7·291	455·7	7,111	—	12,650,000

TABLE OF THE WEIGHT AND STRENGTH OF MATERIALS (cont.)

TIMBER.

Name	Specific Gravity	Lbs. in a Cub. Foot	Tearing Force Lbs. on Sq. In.	Crushing Force Lbs. on Sq. In.	Breaking Force Lbs. on Sq. In.	Modulus of Elasticity Lbs. on Sq. In.
Acacia	·710	44·4	16,000	—	—	—
Alder	·555	34·6	14,186	6,895	9,540	1,087,000
Apple	·793	49·5	19,500	6,499	—	—
Ash	·753	47·0	17,000	9,000	12,200	1,645,000
Beech	·700	43·8	11,500	9,363	9,336	1,354,000
Birch	·750	46·9	15,000	6,402	11,671	1,645,000
Box	1·000	62·5	20,000	10,299	—	—
Cedar	·486	30·8	11,400	5,860	7,420	486,000
Chestnut	·535	33·4	13,300	—	10,656	1,137,000
Cypress	·655	41·0	6,000	—	—	—
Ebony	1·279	79·4	—	19,000	13,000	1,360,000
Elder	·695	43·4	10,230	8,467	—	—
Elm	·544	33·8	13,489	10,331	6,078	700,000
Fir, red pine	·577	36·1	14,300	5,375	8,844	1,458,000
„ pitch pine	·660	41·2	7,818	—	9,792	1,226,000
„ spruce	·512	32·0	10,100	6,500	12,346	1,804,000
„ yellow pine	·461	28·8	—	5,445	—	1,600,000
„ larch	·496	31·0	10,220	5,568	5,943	1,363,000
Greenheart	1·001	62·5	—	—	16,554	2,656,000
Hawthorn	·910	56·8	10,500	—	—	—
Hazel	·860	53·7	18,000	4,600	—	—
Hornbeam	·760	47·4	20,240	7,289	—	—
Laburnum	·920	57·4	10,500	—	—	—
Lancewood	·675	42·1	—	6,614	17,354	812,000
Lignum-vitæ	1·333	83·2	11,800	9,921	11,400	558,000
Lime	·760	47·4	23,500	—	11,202	1,152,000
Mahogany, Honduras	·560	35·0	—	—	11,475	1,593,000
„ Spanish	·853	53·2	21,800	8,198	7,560	1,255,000
„ Australian	·952	59·4	—	9,921	20,238	1,157,000
Oak, British	·934	58·3	10,000	10,055	10,032	1,451,000
„ Riga	·688	43·0	—	—	12,888	1,610,000
„ Dantzic	·756	47·2	12,780	7,723	8,742	1,191,000
„ red	·872	54·4	10,253	5,987	10,596	2,149,000
Poplar	·511	31·9	7,200	5,124	10,260	1,134,000
Sycamore	·590	36·8	13,000	—	9,630	1,036,000
Teak, Indian	·880	55·0	15,000	—	14,600	2,800,000
„ African	·983	61·3	21,000	9,320	14,976	2,305,000
Walnut	·671	41·8	8,130	6,645	8,000	—
Willow	·405	25·3	—	—	6,570	—
Yew	·807	50·3	8,000	—	—	—

Table of the Weight and Strength of Materials (concluded).

Miscellaneous Substances.

Name	Specific Gravity	Weight of a Cub. Foot, Lbs.	Crushing Force. Lbs. on Sq. In.	Name	Specific Gravity	Weight of a Cub. Foot, Lbs.	Crushing Force. Lbs. on Sq. In.
Asphalte . . .	2·50	156	—	Mica . . .	2·79	173	—
Alabaster. . .	1·87	117	—	Mortar . . .	2·48	156	—
Basalt . . .	2·72	170	16,800	Peat, hard . .	1·33	83	—
Brick, common .	2·00	125	—	Plumbago . .	2·27	139	—
„ red . .	2·16	134	808	Porcelain, China .	2·38	149	—
„ Welsh fire .	2·40	150	—	Portland stone .	2·57	161	6,856
Cement, Portland .	1·35	84	5,984	Pumice stone . .	·914	57	—
Chalk . . .	2·77	173	505	Purbeck stone .	2·60	163	9,160
Coal	1·27	79·4	—	Rag stone . .	2·47	154	—
Coke . . .	·744	46	—	Rotten stone . .	1·98	124	—
Freestone . .	2·45	153	6,842	Salt	2·13	133	—
Glass, flint . .	3·078	192	27,500	Sand, fine pit . .	1·52	95	—
„ crown . .	2·52	157	31,000	„ coarse pit .	1·61	100	—
„ common green	2·528	158	31,876	„ river . .	1·88	117	—
„ plate . .	2·76	172	—	Slate . . .	2·62	164	15,000
Gypsum . . .	2·17	135	—	Sugar . . .	1·61	100	—
Granite . . .	2·70	169	12,800	Sulphate of soda .	2·20	137	—
Grindstone . .	2·14	134	—	Sulphur, native .	2·03	127	—
India rubber . .	·934	58·4	—	„ fused .	1·99	124	—
Lime, quick . .	·843	53	—	Tallow . . .	·94	59	—
Limestone . .	2·95	184	9,160	Tar	1·02	63	—
Marble . . .	2·72	170	9,219	Tile, common . .	1·83	113	—

Liquids.

Name	Specific Gravity	Weight of a Cub. Foot, Lbs.	Weight of a Cubic Inch, Ozs.	Name	Specific Gravity	Weight of a Cub. Foot, Lbs.	Weight of a Cubic Inch, Ozs.
Acetic acid . .	1·06	66·4	·615	Oil of olives . .	·915	57·2	·530
Alcohol, proof . .	·916	57	·530	„ turpentine .	·870	54·9	·508
Ether, acetic . .	·866	54	·501	„ whale . .	·923	57·7	·534
„ muriatic .	·730	45·6	·422	Oils, average . .	·880	55·0	·510
„ sulphuric .	·740	46·3	·428	Petroleum . .	·878	54·8	·508
Muriatic acid . .	1·20	75	·694	Sulphuric acid .	1·84	115	1·066
Nitric acid . .	1·27	79·4	·736	Vinegar . . .	1·01	63·1	·585
Oil of aniseed . .	·987	61·6	·570	Water, rain . .	1·00	62·5	·579
„ caraway seed	·905	56·6	·524	„ sea . .	1·03	64·4	·595
„ hempseed .	·926	57·8	·536	Wine, champagne .	·998	62·4	·578
„ lavender .	·894	55·9	·517	„ burgundy .	·991	62·0	·573
„ linseed . .	·940	58·8	·544	„ madeira .	1·04	65·0	·601
„ rapeseed .	·913	57·0	·528	„ port . .	·997	62·3	·577

TABLE OF SIZES OF PIPES FOR PUMPS.

	Suction Pipes		Discharge Pipes	
Size of Pump	Diameter in the Clear	Thickness	Diameter in the Clear	Thickness
Inches	Inches	Inches	Inches	Inches
12	$6\frac{1}{2}$	$\frac{1}{8}$	6	$\frac{5}{32}$
9	4	$\frac{1}{8}$	$3\frac{1}{2}$	$\frac{1}{8}$
7	3	$\frac{1}{8}$*	$2\frac{1}{2}$	$\frac{1}{8}$
	$2\frac{1}{2}$	$\frac{1}{8}$		
$5\frac{1}{2}$	$2\frac{1}{2}$	$\frac{1}{8}$*	2	$\frac{1}{8}$
	2	$\frac{1}{8}$		
$4\frac{1}{2}$	2	$\frac{1}{8}$*	$1\frac{1}{2}$	$\frac{1}{8}$
	$1\frac{1}{2}$	$\frac{1}{8}$		

* Tail pipe to pump.

Note.—All suctions and flood pipes of copper, with the exception of the part of suction pipes coming within 3 feet of the bilge, where they are to be galvanised iron, $\frac{1}{4}''$ thick. It is usual to stop the copper suction pipe at the non-return valve, and then the galvanised iron piping to start from the valve.

Theoretical lift of pump from surface of water to suction valve = 34 feet; but pumps will not draw water over 25 feet. For efficient working the suction should not exceed 15 feet. The leverage of handle for a common pump is generally 6 to 1, so that if P = power on pump handle, and W = weight of water above the bucket, $P = \frac{W}{6}$.

Capacity of Pump.

Let D = diameter of bucket or ram in inches.
L = length of stroke in inches.
n = number of strokes per minute.
C = capacity in gallons per minute.

$$C = \frac{\pi D^2 \times L \times n}{4 \times 277 \cdot 274} = D^2 \times L \times n \times \cdot 034.$$

As pumps always throw less than calculated, deduct $\frac{1}{5}$ of above for slip.

Horse-power of Pump.

Let C = capacity as above calculated.
h = height from suction valve to point of delivery.
Then weight lifted per min. = C × 10; and
∴ work done per min. = C × 10 × h.

$$\text{Horse-power} = \frac{C \times 10 \times h}{33000}.$$

About 50 per cent. must be added to allow for friction and contingencies.

PUMPING ENGINES.

G = number of gallons discharged per minute.
C = number of cubic feet discharged per minute.
D = diameter of pump in inches.
L = length of stroke in feet.
N = number of strokes per minute.
H = horse power to raise G gallons or C feet per minute.
h = height water is to be lifted.

$G = \cdot03401 NLD^2$ $\qquad$ $C = \cdot005456 NLD^2$

$$D = \sqrt{\frac{29\cdot4G}{NL}} \text{ or } \sqrt{\frac{183\cdot3C}{NL}}, \qquad H = \frac{NLD^2h}{97020} \text{ or } \frac{Ch}{15557}$$

HYDRAULIC PRESS.

P = pressure in tons.
D = diameter of ram in inches.
L = distance between fulcrum and axis of small pump.
d = diameter of small pump in inches.
l = length of pump handle from the fulcrum to point of application of power.
f = force applied to pump handle in lbs.

$$P = \frac{D^2fl}{2240d^2L}$$

TABLE OF THE PRESSURE OF WATER AT DIFFERENT HEADS.

H = head in feet. P = pressure in lbs. per sq. foot. p = pressure in lbs. per sq. inch.

H	P	p	H	P	p	H	P	p
1	62·4	·4333	5	312·0	2·1666	30	1872·0	13·0000
1·25	78·0	·5416	6	374·4	2·6000	40	2496·0	17·3333
1·5	93·6	·6500	7	436·8	3·0333	50	3120·0	21·6666
1·75	109·2	·7583	8	499·2	3·4666	60	3744·0	26·0000
2	124·8	·8666	9	561·6	3·9000	70	4368·0	30·3333
3	187·2	1·3000	10	624·0	4·3333	80	4992·0	34·6666
4	249·6	1·7333	20	1248·0	8·6666	90	5616·0	39·0000

DISCHARGE OF WATER FROM SLUICES AND ORIFICES.

V = theoretical velocity due to head of water in feet per second.
H = head of water in feet.
A = area of aperture or outlet in square feet.
Q = quantity discharged in cubic feet per second.
g = force of gravity = 32·2.

v = velocity of real discharge in feet per second.
k = coefficient for different diameters of sluices.

$$V = \sqrt{2gH} \quad = 8{\cdot}025\sqrt{H}$$

$$H = \frac{V^2}{2g} \quad = {\cdot}01553V^2$$

$$Q = Ak\sqrt{2gH} = 8{\cdot}025Ak\sqrt{H}$$

$$A = \frac{Q}{k\sqrt{2gH}} \quad = \frac{Q}{8{\cdot}025k\sqrt{H}}$$

$$v = k\sqrt{2gH} \quad = 8{\cdot}025k\sqrt{H}$$

TABLE OF THE VALUES OF COEFFICIENT k.

For Short Square Tubes						For Short Cylindrical Tubes.					
$\frac{\text{Lgth.}}{\text{Dia.}}$	k	$\frac{\text{Lgth.}}{\text{Dia.}}$	k	$\frac{\text{Lgth.}}{\text{Dia.}}$	k	$\frac{\text{Lgth.}}{\text{Dia.}}$	k	$\frac{\text{Lgth.}}{\text{Dia.}}$	k	$\frac{\text{Lgth.}}{\text{Dia.}}$	k
0	·617	20	·69	50	·59	1	·62	13	·73	49	·60
2	·814	30	·65	60	·56	2	·82	25	·68	60	·56
10	·75	40	·62	100	·48	4	·77	37	·63	100	·48

DISCHARGE OF WATER FROM A CISTERN.

T = time of discharge in seconds.
Q = rate of discharge (found by above formula).
W = volume of water in cistern in cubic feet.

$$T = \frac{2W}{Q} \text{ for vertical-sided cistern.}$$

$$T = \frac{4W}{3Q} \text{ for wedge-shaped cistern.}$$

$$T = \frac{6W}{5Q} \text{ for pyramidal-shaped cistern.}$$

TIME OF FILLING A CISTERN WHEN SUPPLY AND DISCHARGE ARE GOING ON AT THE SAME TIME.

F = cubic feet of water going in per minute.
f = cubic feet of water going out per minute.
T = time required to fill cistern in minutes.
t = time required to empty cistern in minutes.
c = contents of cistern in cubic feet.

$$T = \frac{c}{F - f} \qquad t = \frac{c}{f - F}$$

Pressure of Water on Dock Gates.

D = depth of water in feet.
L = length of one gate in feet.
T = thrust on ribs in lbs.
N = normal pressure on the surface of the gates in lbs.
d = distance from point where gates meet to a right line joining their hinges.

$$T = \frac{31 \cdot 2 D^2 L^2}{d} \qquad N = 32 L D^2$$

Force of Water in Motion.

F = force of water against surface in lbs.
A = area of surface in square feet.
V = velocity of water in feet per second.
V_1 = velocity of water in miles per hour.
V_2 = velocity of water in knots per hour.
θ = sine of angle of incidence with opposing surface.

$$F = \theta A V^2 = 2 \cdot 151 \theta A V_1^2 = 2 \cdot 852 \theta A V_2^2.$$

Table of the Force of Water in Motion.

Velocity in Feet per Second	Pressure in Lbs. per Square Foot	Velocity in Miles per Hour	Pressure in Lbs. per Square Foot	Velocity in Knots per Hour	Pressure in Lbs. per Square Foot
1	1	1	2·1511	1	2·8524
2	4	2	8·6044	2	11·4094
3	9	3	19·3600	3	25·6711
4	16	4	34·4177	4	45·6375
5	25	5	53·7777	5	71·3087
6	36	6	77·4400	6	102·6844
7	49	7	105·4044	7	139·7649
8	64	8	137·6711	8	182·5501
9	81	9	174·2400	9	231·0400
10	100	10	215·1111	10	285·2346
11	121	11	260·2844	11	345·1339
12	144	12	309·7600	12	410·7378
13	169	13	363·5377	13	482·0465
14	196	14	421·6177	14	559·0598
15	225	15	484·0000	15	641·7179
16	256	16	550·6844	16	730·2006
17	289	17	621·6711	17	824·3280
18	324	18	696·9600	18	924·1601
19	361	19	776·5511	19	1029·6969
20	400	20	860·4444	20	1140·9384

Flow of Water through Pipes.

H = loss head of water in feet.
L = length of pipe in feet.
D = diameter of pipe in feet.
Q = quantity discharged in cubic feet per second.
V = velocity of discharge in cubic feet per second.
k = coefficient of friction = ·0258 for rough approximation.

$$H = \frac{kLV^2}{64{\cdot}4D} = {\cdot}02\left(1 + \frac{L}{12D}\right)\frac{LV^2}{64{\cdot}4D}$$

$$V = 8{\cdot}025\sqrt{\frac{HD}{kL}} \qquad k = {\cdot}02\left(1 + \frac{L}{12D}\right) \qquad Q = {\cdot}7854VD^2$$

Table of Coefficients of Friction and Angles of Repose.

R = resistance of friction to the sliding of two surfaces.
P = pressure over the surfaces. k = coefficient of friction.

$$R = Pk$$

Name of Materials	Coefficient of Friction = tan. ϕ	Angle of Repose = ϕ
Hemp on dry oak	·53	28°
„ wet „	·33	$18\frac{1}{2}$°
Iron on stone	·70 to ·30	$35\frac{1}{2}$° to $16\frac{2}{3}$°
Metals on metals, dry	·15 „ ·2	$8\frac{1}{2}$° „ $11\frac{1}{2}$°
„ „ wet	·3	$16\frac{1}{2}$°
Leather „ dry	·56	$29\frac{1}{2}$°
„ „ greasy	·23	13°
Leather on oak	·27 „ ·38	15° „ $19\frac{1}{2}$°
Timber on metals, dry	·5 „ ·6	$26\frac{1}{2}$° „ 31°
„ „ soapy	·2	$11\frac{1}{2}$°
„ stone	·40	22°
„ timber, dry	·25 „ ·5	14° „ $26\frac{1}{2}$°
„ „ soaped	·2 „ ·04	$11\frac{1}{2}$° „ 2°

Simple and Compound Interest.

P = principal in pounds.
A = amount of principal and interest after n years.
r = rate of interest of £1 for one year.
n = number of years.

Simple $P = \frac{A}{1 + nr}$ $A = P(1 + nr)$ $r = \frac{A - P}{Pn}$

Compound $P = \frac{A}{(1 + r)^n}$ $A = P(1 + r)^n$ $r = \sqrt[n]{\frac{A}{P}} - 1.$

CONIC SECTIONS.

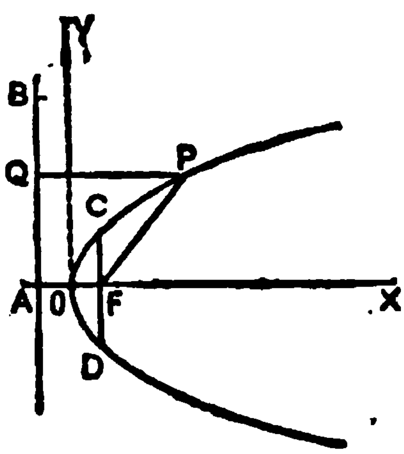
DEFINITION.—The locus of a point which moves so that its distance from a fixed point is always in a constant ratio to its perpendicular distance from a fixed straight line is called a conic section.

The fixed point is called the focus, the constant ratio the eccentricity, and the fixed straight line the directrix.

The straight line passing through the focus and perpendicular to the directrix is called the axis.

PARABOLA.

FIG. 268.



The conic section is called a parabola when the eccentricity is equal to unity.

In fig. 268, F is the focus, AB the directrix, AX the axis, O the intersection of the curve with the axis, OY a line perpendicular to AX, and P any point on the curve; then PQ = PF.

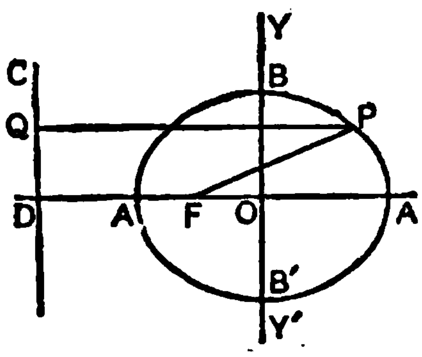
The equation of the curve with OY and OX as axes is

$$y^2 = 4\,ax.$$

A parabola may also be defined as the section of a cone cut by a plane parallel to one of the slant sides.

ELLIPSE.

FIG. 269.



The conic section is called an ellipse when the eccentricity is less than unity.

In fig. 269 CD is the directrix, F the focus, DA′ the major axis, O the middle point of AA′, and BB′ the minor axis, down through O, perpendicular to the axis, and P any point on the curve so that $\frac{PF}{PQ}$ = the eccentricity e. The equation to the curve with OA′, OY as axes is—

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1.$$

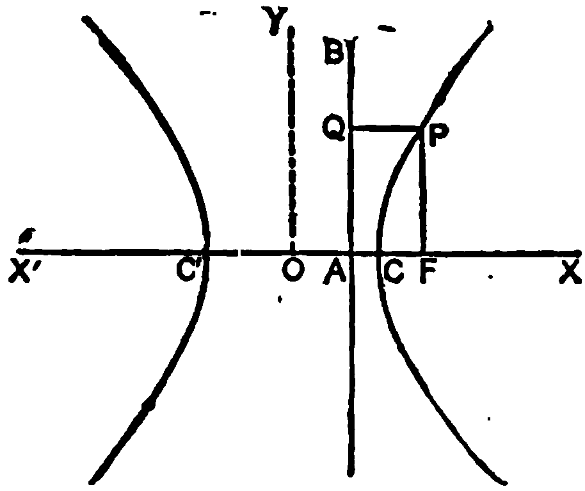
An ellipse may also be defined as the intersection of a cone by a plane passing through its slant sides, but not perpendicular to the axis.

HYPERBOLA.

The conic section is called a hyperbola when the eccentricity is greater than unity.

In fig. 270 AB is the directrix, F the focus, XX′ the axis, CC′ the points where the curve intersects the axis, OY a line

FIG. 270.



drawn through the middle point of CC′ perpendicular to the axis, and P any point on either branch of the curve.

Then $\frac{PF}{PQ}$ = the eccentricity e.

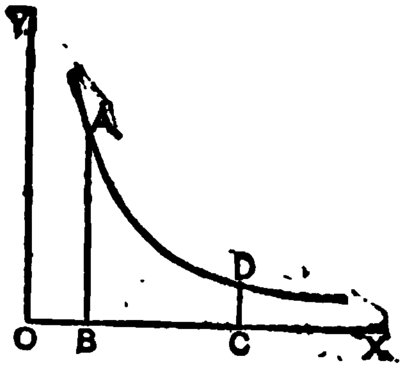
Taking OX and OY as axes the equation to the curve is—

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} = 1.$$

If the sides of a cone be produced beyond the vertex so as to form a second cone with the same axis as the first, and these two cones be cut by a plane, the section will be a hyperbola.

If b be made equal to a in the above equation, it becomes $x^2 - y^2 = a^2$, which is a *rectangular* hyperbola. By turning

FIG. 271.



the axis through an angle of 45°, the equation becomes of the form $xy = c^2$.

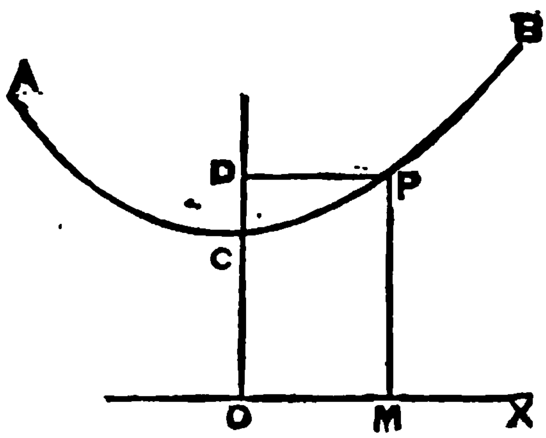
To find the area of the figure ADCB, bounded by the hyperbola

$xy = c^2$, two ordinates, AB and DC (fig. 271), and the base, OX, multiply c^2 by the Napierian logarithm of $\frac{OC}{OB}$. The result will be the area.

CATENARY.

If a uniform chain be freely suspended from two points, A and B, the curve in which it will hang is termed a common catenary; the parameter OC is equal to the length of a piece of

FIG. 272.



the chain whose weight is equal to the tension at the lowest point C in the curve.

The directrix OX is a horizontal line drawn through the extremity O of the parameter.

The tension at any point P in the curve is equal to the length of a piece of the chain whose weight is equal to the tension at the point, and is thus equal to the ordinate PM.

Equations to the Catenary (see fig. 272).

x = abscissa. y = ordinate. c = tension at C.
S = length CP of chain.
ϵ = base of hyperbolic logarithms = 2·71828 . . .

Cartesian.

$$y = \sqrt{(c^2 + S^2)} = \frac{c}{2}\left(\epsilon^{\frac{x}{c}} + \epsilon^{-\frac{x}{c}}\right)$$

$$S = \sqrt{y^2 - c^2} = \frac{c}{2}\left(\epsilon^{\frac{x}{c}} - \epsilon^{-\frac{x}{c}}\right)$$

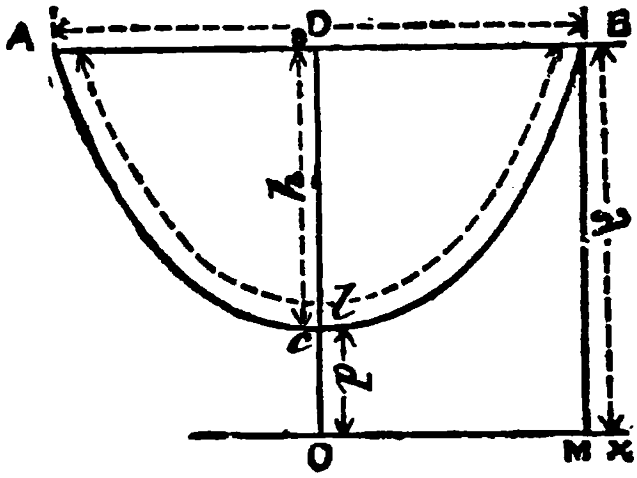
Approximate Equation.

$$x^2 = 2c(y - c) - \tfrac{1}{3}(y - c)^2$$

Formulæ for the Catenary when the points of support are in the same horizontal plane (see fig. 273).

s = span.
h = height or dip.
p = parameter.
l = length of chain.
w = weight of unit of chain.
t = tension at A or B.
c = tension at c.
y = ordinate at A or B.

FIG. 273.



$$p=\frac{c}{w}$$

$$y=\frac{t}{w}=p+h=p+\frac{s^2}{8p}+\frac{s^4}{384p^3}+\frac{s^6}{46080p^5}+\&c.$$

$$t=yw \qquad c=pw$$

$$l=s+\frac{s^3}{24p^2}+\frac{s^5}{1920p^4}+\&c.$$

$$h=\frac{s^2}{8p}+\frac{s^4}{384p^3}+\frac{s^6}{46080p^5}+\&c.$$

Approximate Formulæ.

$$p=\tfrac{1}{7}\left[4y+\sqrt{(3y)^2-21\left(\frac{s}{2}\right)^2}\right]=\frac{s^2}{8h}+\frac{h}{6}\text{ nearly.}$$

$$h=\tfrac{1}{7}\left[3y-\sqrt{(3y)^2-21\left(\frac{s}{2}\right)^2}\right]=\frac{s^2}{8y}\text{ nearly.}$$

$$l=\sqrt{\left(s^2+\frac{16}{3}h^2\right)}=s+\frac{8h^2}{3s}\text{ nearly.}$$

$$y=\frac{s^2}{8h}+\frac{7h}{6}=\frac{s^2}{8h}\text{ nearly.}$$

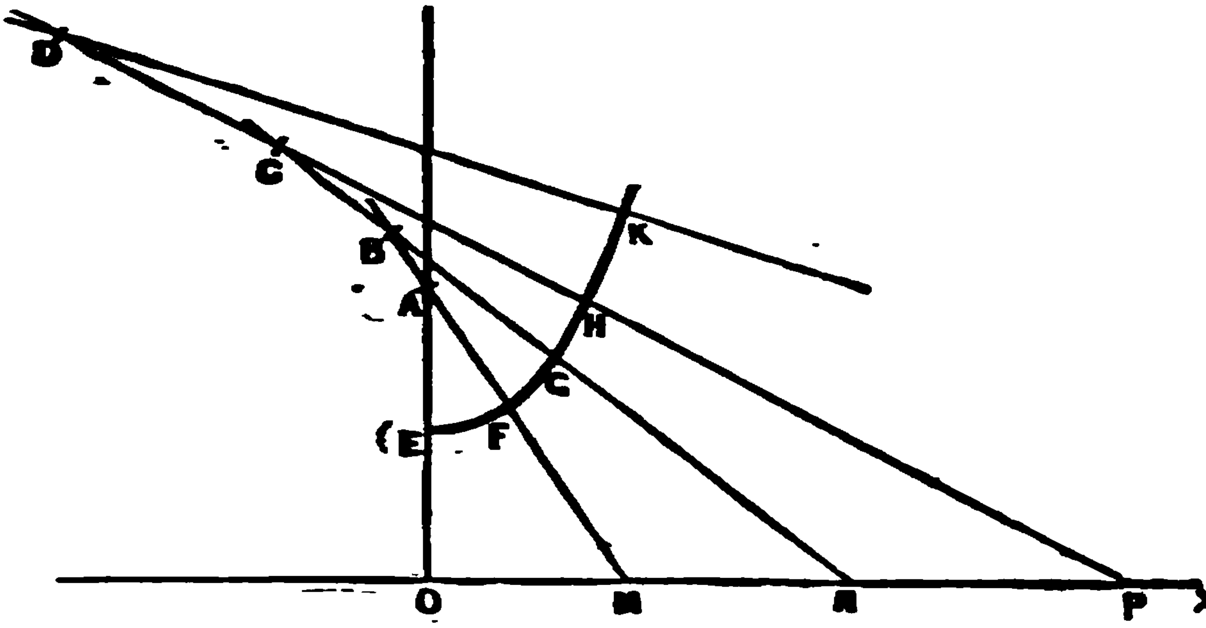
Catenaries that make equal angles at the points of suspension with their ordinates or horizontal dimensions are similar figures.

Table of Relations of Catenarian Curves, the Parameter being taken as Unity.

Angle of Suspension	h	$\frac{s}{2}$	$\frac{l}{2}$	y	$\frac{s}{2} \div h$
1° 0′	·00015	·01745	·01745	1·0001	114·586
2° 0′	·00061	·03491	·03492	1·0006	57·279
3° 0′	·00137	·05238	·05241	1·0014	38·171
4° 0′	·00244	·06987	·06993	1·0024	28·613
5° 0′	·00382	·08738	·08749	1·0038	22·874
6° 0′	·00551	·10491	·10510	1·0055	19·046
7° 0′	·00751	·12248	·12278	1·0075	16·309
8° 0′	·00983	·14008	·14054	1·0098	14·254
9° 0′	·01247	·15773	·15838	1·0125	12·654
10° 0′	·01543	·17542	·17633	1·0154	11·372
11° 0′	·01872	·19318	·19438	1·0187	10·820
12° 0′	·02234	·21099	·21256	1·0223	9·444
13° 0′	·02630	·22887	·23087	1·0263	8·701
14° 0′	·03061	·24681	·24933	1·0306	8·062
15° 0′	·03528	·26484	·26795	1·0353	7·508
16° 0′	·04030	·28296	·28675	1·0403	7·021
17° 0′	·04569	·30116	·30573	1·0457	6·591
18° 0′	·05146	·31946	·32492	1·0515	6·208
19° 0′	·05762	·33786	·34433	1·0576	5·863
20° 0′	·06418	·35637	·36397	1·0642	5·553
21° 0′	·07114	·37502	·38386	1·0711	5·271
22° 0′	·07853	·39376	·40403	1·0786	5·014
23° 0′	·08636	·41267	·42447	1·0864	4·778
24° 0′	·09484	·43169	·44523	1·0946	4·562
25° 0′	·10338	·45087	·46631	1·1034	4·361
26° 0′	·11260	·47021	·48773	1·1126	4·176
28° 0′	·13257	·50940	·53171	1·1326	3·843
30° 0′	·15470	·54930	·57735	1·1547	3·551
32° 4′	·18004	·5912	·62649	1·1800	3·284
34° 16′	·21003	·6371	·68130	1·2100	3·034
36° 52′	·24995	·6932	·74991	1·2499	2·773
39° 11′	·29011	·7443	·81510	1·2901	2·567
41° 44′	·34004	·8029	·89201	1·3400	2·362
44° 0′	·39016	·8566	·96569	1·3902	2·196
46° 1′	·43999	·9066	1·0361	1·4400	2·060
48° 11′	·49981	·9623	1·1178	1·4998	1·925
50° 8′	·56005	1·0142	1·1974	1·5800	1·811
52° 9′	·62973	1·0706	1·2869	1·6297	1·699
54° 13′	·71021	1·1304	1·3874	1·7102	1·592
56° 28′	·81021	1·1995	1·5089	1·8102	1·481
58° 3′	·88972	1·2510	1·6034	1·8897	1·416
60° 0′	1·0000	1·3169	1·7321	2·0000	1·317
64° 6′	1·2894	1·4702	2·0594	2·2894	1·140
67° 28′	1·6095	1·6135	2·4102	2·6095	1·002
67° 32′	1·6168	1·6164	2·4182	2·6168	0·9998

To Construct a Catenary Geometrically.

Fig. 274.

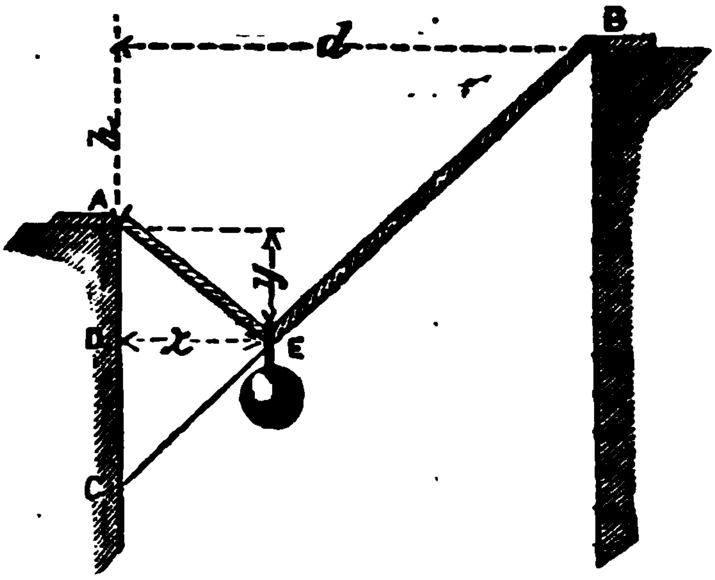


Let E be the lowest point in the curve, OE its parameter, and OX its directrix. Make AE equal to OE; then with A as centre and AE as radius describe the small arc EF. Join FA and produce it to M and to B, making BF equal to FM; then with B as centre and BF as radius describe the small arc FG. Join BG and produce it to N and to C, making CG equal to GN; then with C as centre and CG as radius describe the small arc GH. Proceed in a similar manner till the curve is of the required length.

Weighted Rope.

To determine the position a weight will take when hung on a rope suspended from two points not in the same horizontal plane.

Fig. 275.



Let A and B be the two points of suspension; make BC equal to the length of the rope; bisect AC in D: the point E where the perpendicular DE cuts BC will be the point at which the weight will hang.

l = length of rope.

d = distance between points of suspension.

h = height of one support above the other.

x and y = co-ordinates of the point.

$$y = \frac{\sqrt{(l^2 - d^2)} - h}{2} \qquad x = \frac{yd}{\sqrt{(l^2 - d^2)}}$$

MECHANICAL POWERS.

THE power applied and the weight lifted are directly proportional to the distances moved through by each body in a given time.

W = weight to be raised.
P = power applied.
D = distance of power from fulcrum.
d = distance of weight from fulcrum.
n = number of movable pulleys.
L = length of inclined plane and wedge.
H = height of inclined plane.
C = circumference described by P.
t = thickness of wedge.
S = distance moved through by P.
s = distance moved through by W.
R = resistance to wedge.
p = pitch of screw.

General Formulæ for all the Powers.

$$W = \frac{SP}{s} \qquad P = \frac{Ws}{S} \qquad S = \frac{Ws}{P} \qquad s = \frac{SP}{W}$$

The Lever and Wheel and Axle.

$$W = \frac{PD}{d} \qquad P = \frac{Wd}{D} \qquad D = \frac{Wd}{P} \qquad d = \frac{PD}{W}$$

Fig. 276.

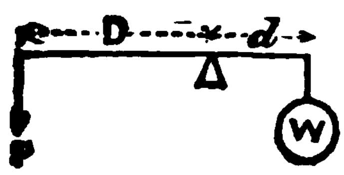


Fig. 277.

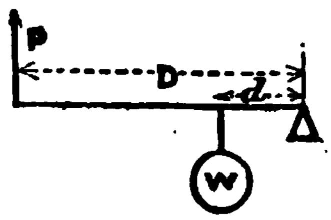


Fig. 278.

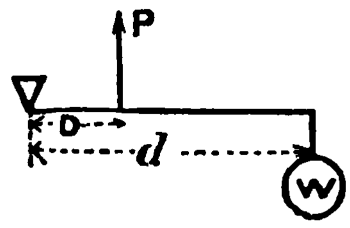
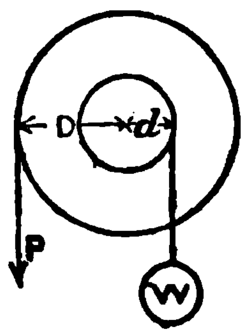


Fig. 279.



THE PULLEY.

$$W = 2Pn \qquad P = \frac{W}{2n}$$

FIG. 280.

ONE MOVABLE PULLEY.

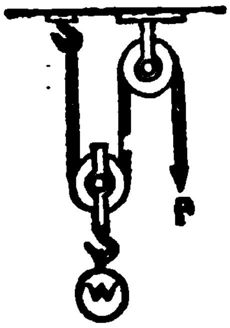
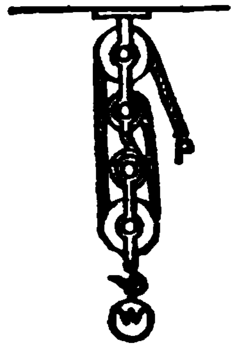


FIG. 281.

TWO MOVABLE PULLEYS.



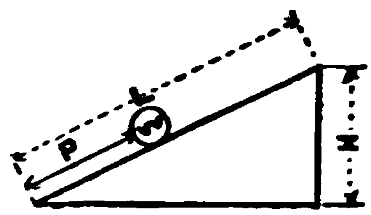
Note.—For revolutions of wheels see p. 328.

THE INCLINED PLANE.

$$W = \frac{PL}{H} \qquad P = \frac{WH}{L}$$

$$H = \frac{PL}{W} \qquad L = \frac{WH}{P}$$

FIG. 282.



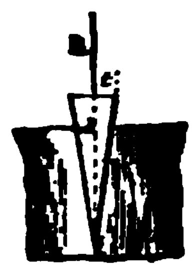
THE WEDGE.

$$R = \frac{PL}{t}$$

$$P = \frac{Rt}{L}$$

$$t = \frac{PL}{R}$$

FIG. 283.

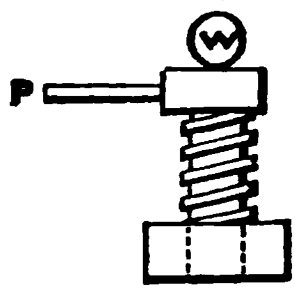


THE SCREW.

$$W = \frac{PC}{p} \qquad P = \frac{Wp}{C}$$

$$p = \frac{PC}{W} \qquad C = \frac{Wp}{P}$$

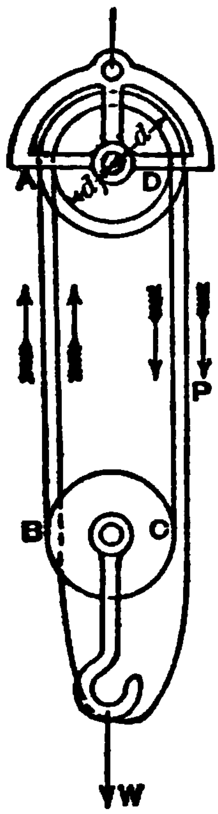
FIG. 284.



Note.—One-third more power than is obtained by the foregoing formulæ is generally allowed, in order to overcome the resistance due to friction, &c., weight and power being in equilibrium.

Differential Pulley.

Fig. 285.



A *Differential Pulley* consists of two blocks (see fig. 285). The upper block contains two sheaves of slightly different diameters, secured so as to revolve together. A chain is wound on the blocks as shown, the blocks having projections on their rims to fit the chain and prevent slipping.

Suppose the upper block makes one revolution: Then the length of loop ABCD is shortened by a length = circumference large sheave, and the loop is lengthened = circumference of small sheave.

$$\text{Circumference of large sheave} = 2\pi d,$$
$$\text{,, \quad ,, small sheave} = 2\pi d_1;$$

$$\therefore \text{ Difference in length of loop} = 2\pi(d-d_1),$$

and the weight will be raised $\pi(d-d_1)$.

If P = force acting on chain, friction neglected, for one revolution of wheel P moves $2\pi d$;

$$\therefore \text{ P} \times 2\pi d = \pi(d-d_1)\text{W, and P} = \frac{d-d_1}{2d}\text{W}.$$

Pulleys with Friction.

$$\text{PS} = \text{W}s + k\text{W}s + p'\text{S},$$

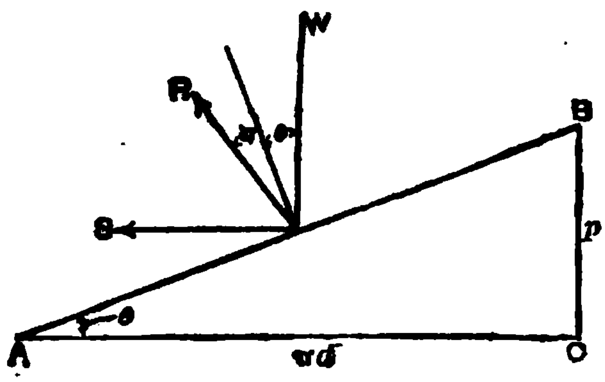
where p' and k are constants which can be determined for every system of pulleys by two experiments.

If the weight to be lifted is very large, p' can be neglected; if very small, k can be neglected.

Efficiency of Screws.

Efficiency of Screws.—Let AB be one turn of the screw developed, then BC = pitch, and AC = circumference of screw,

Fig. 286.



W = weight lifted, R = reaction of screw thread. When R makes an angle ϕ with the normal = angle of repose, coefficient of

friction $=\mu$. Now R is caused by the power applied to turn the screw; $\therefore$ its vertical component $=$ W, and its horizontal component S is such that if P $=$ moment of force used, $P = S \times \frac{d}{2}$;

$$\therefore P = \frac{Rd}{2}\sin(\theta+\phi), \text{ and } W = R\cos(\theta+\phi).$$

Work done by power in one revolution $= P + 2\pi = R\pi d\sin(\theta+\phi)$.

Work done on weight $= Wp = Rp\cos(\theta+\phi)$.

$$\text{Efficiency} = \frac{\operatorname{Tan}\theta}{\operatorname{Tan}(\theta+\phi)}.$$

This is a maximum when $\theta = 45^\circ - \frac{1}{2}\phi$.

Then taking $\operatorname{Tan}\phi = 2\operatorname{Tan}\frac{\phi}{2}$, we get

$$\text{Maximum efficiency} = \left(\frac{1-\frac{1}{2}\mu}{1+\frac{1}{2}\mu}\right)^2.$$

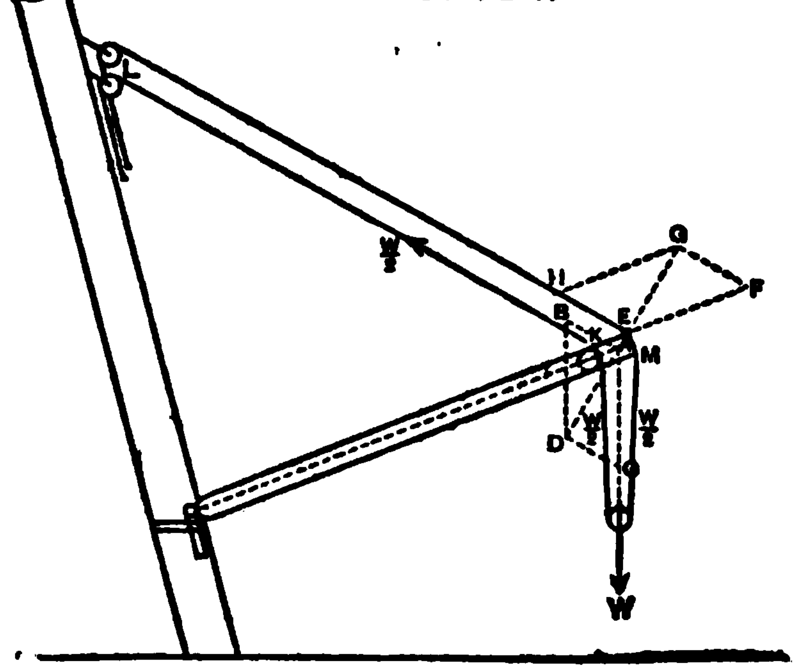
Conversely, if action be reversed,

$$\text{Efficiency} = \frac{\operatorname{Tan}(\theta+\phi)}{\operatorname{Tan}\theta}.$$

Ship's Derrick. Strains on Topping Lift, &c.

Let W $=$ weight suspended by lower block, then strains on the rope are $=\frac{W}{2}$ for each portion (see fig. 287). To find resultant

FIG. 287.



of W and $\frac{W}{2}$ acting up KL, construct the parallelogram ABCD so

that AB $= \frac{W}{2}$ and is parallel to KL. AC = W and is vertical. Then AD represents in magnitude and direction the resultant of W, and $\frac{W}{2}$ acting up KL. Through E draw EG parallel to AB, and make EG = AD. Construct the parallelogram EFGH; then EF represents the force acting along the derrick, and EH represents strain on topping lift. If an additional block is fitted at M, the strain on KL $= \frac{W}{3}$, and if a double block is fitted at E, and a single block on mast, the strain on each part of the topping lift is only $\frac{1}{4}$ EH.

Note.—The greatest strain is brought on the topping lift when the derrick is horizontal.

BELT GEARING.

Length of Crossed Belts.—If two pulleys of diameters D and d distant c apart from centre to centre, be connected by a crossed belt, the total length of the belt =

$$\left(\frac{\pi}{2} + \text{Sin}^{-1}\frac{D+d}{2c}\right)(D+d) + \sqrt{4c^2 - (D+d)^2}.$$

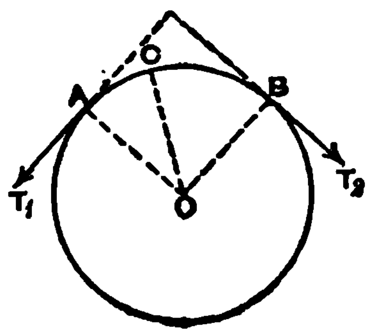
This length is constant provided that the distance between the centres and also the sum of the diameters are constant. In designing speed cones for a lathe, the same belt will drive equally well on all if the sum of the diameters of each pair of pulleys be the same.

Length of Open Belts.—No simple exact rule can be given, but the following, though approximate, is generally accurate enough for practical purposes. Let one pair of pulleys have diameters D_1 and d_1. It is required to find the diameters of another pair of pulleys of different ratio, but driven by the same belt. Treat them first as if the belt were crossed, and find the diameters D_2 and d_2 of a second pair, so that $D_2 + d_2 = D_1 + d_1$. Then calculate $(D_1 + d_1) + \frac{(D_1 - d_1)^2 - (D_2 - d_2)^2}{4\pi C}$, and taking this expression as the sum of the two required pulleys, and $D_2 - d_2$ as the difference, recalculate D_2 and d_2, which will be the diameters required.

Resistance to Slipping.—A and B points where belt leaves pulley. T_1 and T_2 tension of belt at A, B when on the point of slipping. C any point between A, B; and T tension at C. AOB $= \theta$ in circular measure; arc AC $= s$; AO $= r$. Normal pressure of belt on pulley per unit of arc $= p$, coefficient of friction $= \mu$.

Consider a small length, ds, of the belt at C; the tensions at its ends are T and T + dT; so that $\frac{d\text{T}}{ds}$ is the increase of tension per unit-length of the arc of contact. Now friction in unit-length of belt $= \mu p$;

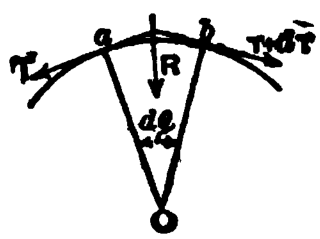
FIG. 288.



$$\therefore \frac{d\text{T}}{ds} = \mu p.$$

The pressure R on the arc ab is the resultant of the tensions T and T + dT acting tangentially at the extremities of the arc.

FIG. 289.



Neglecting dT, we have $\text{R} = 2\text{T} \sin \frac{d\theta}{2} = \text{T}d\theta$ nearly;

but $\text{R} = pds$; $\quad \therefore p = \text{T}\frac{d\theta}{ds} = \frac{\text{T}}{r}$, and $ds = rd\theta$;

then $\quad \frac{d\text{T}}{ds} = \frac{d\text{T}}{rd\theta} = \mu\frac{\text{T}}{r}$, and $\frac{d\text{T}}{\text{T}} = \mu d\theta.$

$$\int_{\text{T}_1}^{\text{T}_2} = \frac{d\text{T}}{\text{T}} = \mu\int_0^\theta d\theta.$$

$$\text{Hyp. log. } \frac{\text{T}_2}{\text{T}_1} = \mu\theta. \qquad \text{Let } \frac{\text{T}_2}{\text{T}_1} = k,$$

$k = e^{\mu\theta}$I, where $e =$ the base of the system of natural logarithms $= 2.71828.$

Greatest Value of the Ratio of Tensions on Light and Slack Sides of Belting from Equation I.

Angle embraced by Belt $=\theta$			Ratio of Tensions $=k$			
In Degrees	In Circular Measure	In Fraction of Circumference	$\mu=0{\cdot}2$	$\mu=0{\cdot}3$	$\mu=0{\cdot}4$	$\mu=0{\cdot}5$
30	·524	·083	1·110	1·170	1·233	1·299
45	·785	·125	1·170	1·266	1·369	1·481
60	1·047	·167	1·233	1·369	1·521	1·689
75	1·309	·208	1·299	1·481	1·689	1·924
90	1·571	·250	1·369	1·602	1·874	2·193
105	1·833	·319	1·443	1·733	2·082	2·500
120	2·094	·334	1·521	1·875	2·312	2·851
135	2·356	·375	1·602	2·027	2·565	3·247
150	2·618	·417	1·689	2·194	2·849	3·702
165	2·880	·458	1·778	2·372	3·163	4·219
180	3·142	·500	1·875	2·566	3·514	4·808
195	3·403	·541	1·975	2·776	3·901	5·483
210	3·665	·583	2·082	3·003	4·333	6·252
240	4·188	·666	2·311	3·514	5·340	8·119
270	4·712	·750	2·566	4·112	6·589	10·55
300	5·236	·833	2·849	4·808	8·117	13·70

Let P = resistance at circumference of driven pulley, then $P = T_2 - T_1$; H = horse-power transmitted, and V = velocity of belt in feet per minute; then $PV = 33000\,H$, and $\therefore\ T_2 - T_1 = \frac{33000\,H}{V}$.

If N = number of revolutions of pulley per minute, d = diameter of pulley in inches; then velocity of pulley $= \frac{\pi d N}{12} = V$;

$$\therefore\ T_2 - T_1 = \frac{33000\,H \times 12}{\pi d N} = \frac{396000\,H}{\pi d N}.$$

The safe working tension of leather belts = 320 lbs. per square inch of section.

The speed of ordinary shop belts varies from 1,000 to 1,500 feet per minute. Lathe belts are driven up to 3,000 feet per minute. The coefficient of friction between ordinary belting and cast-iron pulleys is about ·423.

FORCE, POWER, AND WORK. (*John W. Nystrom.*)

S = space in feet passed through by the force F in the time T.
F = force or pressure in lbs.
V = velocity in feet per second.
T = time of operation in seconds.
P = power in foot lbs. of one pound raised one foot per second.
H = horse power of 550 lbs. raised one foot per second.
W = physical work expressed in workman days of 1,980,000 foot lbs.
M = weight in lbs. of moving mass, or the weight of a mass acted upon by a mechanical force.
G = acceleration of the combined gravity and mechanical force.
g = accelerating force of gravity = 32·166 feet per second.
L = number of labourers employed (not workman days).
D = number of days of eleven working hours.
N = number of horses (not horse power).
n = number of blows of steam hammer or pile-driver.

Note.—By a workman day is meant a man's day's work of 11 hours in the day when the work done is supposed to be equal to the work accomplished by one horse-power in the time of one hour.

FORMULÆ FOR MECHANICAL WORK.

$$S = VT = \frac{PT}{F} = \frac{550TH}{F} = \frac{550 \times 3600W}{F}$$

$$F = \frac{P}{V} = \frac{550HT}{S} = \frac{550 \times 3600W}{VT} = \frac{550 \times 3600W}{S}$$

$$V = \frac{S}{T} = \frac{P}{F} = \frac{550H}{F} = \frac{550 \times 3600W}{FT}$$

$$T = \frac{S}{V} = \frac{SF}{P} = \frac{SF}{550H} = \frac{550 \times 3600W}{FV}$$

$$P = FV = \frac{FS}{T} = 550H = \frac{550 \times 3600W}{T}$$

$$H = \frac{P}{550} = \frac{FV}{550} = \frac{FS}{550T} = \frac{3600W}{T}$$

$$W = \frac{FVT}{550 \times 3600} = \frac{FS}{550 \times 3600} = \frac{PT}{550 \times 3600} = \frac{HT}{3600}$$

$$N=\frac{L}{11}=\frac{W}{11D}=\frac{FV}{550}=\frac{FS}{11\times550\times3600D}$$

$$D=\frac{W}{L}=\frac{W}{11N}=\frac{50W}{FV}=\frac{FS}{550\times3600L}$$

$$W=DL=11DN=\frac{FVD}{50}=\frac{F^2VS}{50\times550\times3600L}$$

Formulæ for Work under the Action of Gravity.

$$S=\frac{gT^2}{2}=\frac{VT}{2}=\frac{PT}{2M}=\frac{4\times550^2H^2}{2gM^2}=\frac{550\times3600W}{M}$$

$$M=\frac{2\times550\times3600W}{gT^2}=\frac{550\times3600W}{S}=\frac{2\times550H}{\sqrt{2gS}}=\frac{550\times3600Wg\times2}{V^2}$$

$$V=gT=\frac{2S}{T}=\frac{2\times550H}{M}=\sqrt{2gS}=\sqrt{\frac{550\times3600gW\times2}{M}}$$

$$T=\frac{2\times550H}{gM}=\sqrt{\frac{2S}{g}}=\sqrt{\frac{550\times3600\times2W}{gM}}$$

$$P=\frac{MTg}{2}=\frac{MV}{2}=\frac{M2S}{T}=550\times3600W\sqrt{\frac{g}{2S}}$$

$$H=\frac{MTg}{2\times550}=\frac{M\sqrt{2gS}}{2\times550}=\frac{MV}{2\times550}=\frac{3600W}{T}$$

$$W=\frac{MV^2}{2\times550g\times3600}=\frac{MS}{550\times3600}=\frac{P\sqrt{\frac{2S}{g}}}{550\times3600}=\frac{H\sqrt{\frac{2S}{g}}}{3600}$$

$$L=\frac{MSn}{550\times3600D}$$

$$D=\frac{MSn}{550\times3600L}$$

$$N=\frac{MSn}{11\times550\times3600D}$$

$$W=\frac{MSn}{550\times3600}$$

Note.—One horse-power = 550 foot lbs. per second = 33,000 foot lbs. per minute = 1,980,000 foot lbs. per hour.

TABLE OF WORK DONE BY MEN AND ANIMALS. (*From Twisden's 'Practical Mechanics.'*)

NATURE OF LABOUR	Daily Duration of Work in Hours	No. of Units of Work per Day	No. of Units of Work per Minute	Weight Raised, or Mean Pressure, in Lbs.	Velocity in Feet per Minute
1. *Raising Weights Vertically.*					
A man mounting a gentle incline or ladder without burden—i.e. raising his own weight	8·0	203,200	4,230	145	29
Labourer raising weights with rope and pulley, the rope returning without load	6·0	563,000	1,560	40	39
Labourer lifting weights by hand	6·0	531,000	1,480	44	34
Labourer carrying weights on his back up a gentle incline or up a ladder, and returning unladen	6·0	406,000	1,130	145	8
Labourer wheeling materials in a barrow up an incline of 1 in 12, and returning with empty barrow	10·0	313,000	520	130	4
Labourer lifting earth with a spade to a mean height of 5¼ feet	10·0	281,000	470	6	78
2. *Action on Machines.*					
Labourer walking and pushing or pulling horizontally	8·0	150,000	3,130	27	116
Labourer turning a winch . .	8·0	1,250,000	2,600	18	144
Labourer pushing and pulling alternately in a vertical direction	8·0	1,146,000	2,390	11	216
Horse yoked to a cart and walking	10·0	15,688,000	26,150	150	175
Horse yoked to a whim gin .	8·0	8,440,000	17,600	100	175
Do. do., trotting . . .	4·5	7,036,000	26,060	66⅔	391

One man can lift with both hands 236 lbs.

" " " support on his shoulders 330 lbs.

A man's strength is greatest in raising a weight when his weight is to that of his load as 4 is to 3.

Note.—In the above table the unit of work is taken at a pressure of 1 lb. exerted through 1 foot.

TABLE GIVING THE USEFUL EFFECT OF AGENTS EMPLOYED IN THE HORIZONTAL TRANSPORT OF BURDENS. (*From Twisden's 'Practical Mechanics.'*)

AGENT	Duration of Daily Work	Useful Effect Daily	Useful Effect per Minute	Weight Transported in Lbs.	Velocity in Feet per Minute
Man walking on a horizontal road without burden—that is, transporting his own weight	10·0	25,398,000	42,330	145	292
Labourer transporting material in a truck on two wheels, returning with it empty for a new load	10·0	13,025,000	21,710	220	99
Do. do., with a wheel-barrow .	10·0	7,815,000	13,030	130	160
Labourer walking with a weight on his back	7·0	5,470,000	13,030	90	145
Labourer transporting materials on his back, and returning unburdened for a new load	6·0	5,087,000	14,100	145	97
Do. do., on a hand-barrow . .	10·0	4,298,000	7,160	110	65
Horse transporting material in a cart, walking, always laden	10·0	200,582,000	334,300	1,500	223
Do. do., trotting	4·5	90,262,000	334,300	750	44
Do. do., transporting materials in a cart, returning with the cart empty for a new load	10·0	10,940,800	182,350	1,500	121
Horse walking with a weight on his back	10·0	34,385,000	57,310	270	212
Do. do., trotting . . .	7·0	32,072,000	76,410	180	424

Note.—The useful effect in the above table is the product of the weight in lbs. and the distance in feet.

BOARD OF TRADE REGULATIONS FOR MARINE BOILERS, ETC.

IRON BOILERS AND SUPERHEATERS.

Pressures on Flat Surfaces.

WITH flat surfaces the pressure on stays supporting them should not exceed 7,000 lbs. per sq. in. of net section, for solid iron, screwed stays; and the stress should not exceed 5,000 lbs. when the stays have been welded or worked in the fire; but if in any case a greater pressure is required, where the flat surfaces are stiffened by T or L irons, the mode of stiffening must be submitted to the Board of Trade for approval.

To find the area of any diagonal stay

RULE.—Find the area of a direct stay needed to support the surface; multiply this area by the length of the diagonal stay, and divide the product by the length of a line drawn at right angles to the surface supported at the end of the diagonal stay.

Note.—When gusset stays are used their area should be in excess of that found by the above rule.

Girders for Flat Surfaces.

When the tops of combustion boxes, or other parts of a boiler, are supported by solid rectangular girders, the following formula may be used for finding the working pressure to be allowed on the girders, assuming that they are not subjected to a greater temperature than the ordinary heat of steam, and in the case of combustion chambers that the ends are fitted to the edges of the tube plate and the back plate of the combustion box:—

FORMULA.

P = working pressure.
L = length of girder in feet.
D = depth of girder in inches.
T = thickness of girder in inches.
W = width of combustion box in inches.
p = pitch of supporting bolts in inches.
d = distance between the girders from centre to centre in inches.
k = 500 when the girder is fitted with one supporting bolt,
= 750 when fitted with two or three supporting bolts,
= 850 when fitted with four supporting bolts.

$$P = \frac{k \times D2 \times T}{(W - p)d \times L}.$$

Plates for Flat Surfaces.

The pressure on plates forming flat surfaces may be found by the following formula:—

FORMULA.

W = working pressure.
T = thickness of plate in sixteenths of an inch.
S = surface supported in square inches.
k = constant according to the following circumstances:—

k = 100 when the plates are not exposed to the impact of heat or flame and the stays are fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plate they cover.

$k=90$ when the plates are not exposed to the impact of heat or flame and the stays are fitted with nuts only.

$k=67\frac{1}{2}$ when the plates are not exposed to the impact of heat or flame and the stays are screwed into the plates and riveted over.

$k=60$ when the plates are exposed to the impact of heat or flame and steam in contact with the plates, and the stays fitted with nuts and washers, the latter being at least three times the diameter of the stay and two-thirds the thickness of the plates they cover.

$k=54$ when the plates are exposed to the impact of heat or flame and steam in contact with the plate, and the stays fitted with nuts only.

$k=80$ when the plates are exposed to the impact of heat or flame with water in contact with the plates, and the stays screwed into the plate and fitted with nuts.

$k=60$ when the plates are exposed to the impact of heat or flame, with water in contact with the plate, and the stays screwed into the plate having the ends riveted over to form a substantial head.

$k=36$ when the plates are exposed to the impact of heat or flame and steam in contact with the plates, with the stays screwed into the plate and having the ends riveted over to form a substantial head.

$$\mathrm{W}=\frac{k\times(\mathrm{T}+1)^2}{\mathrm{S}-6}.$$

Cylindrical Boilers.

When cylindrical boilers are made of the best material, with all the rivet holes drilled in place and all the seams fitted with double butt-straps, each of at least $\frac{5}{8}$ the thickness of the plates they cover, and all the seams at least double-riveted with rivets having an allowance of not more than 75 per cent. over the single shear, and provided that the boilers have been open to inspection during the whole period of construction, then 5* may be used as the factor of safety. The tensile strength of the iron is to be taken as equal to 47,000 lbs. per square inch with the grain, and 40,000 lbs. across the grain. But when the above conditions are not complied with, the additions in the following scale should be made to the factor of safety, according to the circumstances of each case.

* *Note.*—If the iron be tested and the elongation measured in a length of 10 inches is not less than 14 per cent. with, and 8 per cent. across the grain, and the surveyors otherwise satisfied as to the quality of the plates and rivets, then 4·5 may be used instead of 5.

TABLE GIVING THE CONSTANTS TO BE ADDED TO THE FACTOR OF SAFETY FOR CYLINDRICAL BOILERS.

Mark	Constants	Circumstances in which the Constants have to be added
A	·15	When the holes are fair and good in the longitudinal seams, but drilled out of place after bending.
B	·3	When the holes are fair and good in the longitudinal seams, but drilled out of place before bending.
C	·3	When the holes are fair and good in the longitudinal seams, but punched after bending.
D	·5	When the holes are fair and good in the longitudinal seams, but punched before bending.
E*	·75	When the holes are not fair and good in the longitudinal seams.
F	·1	When the holes are fair and good in the circumferential seams, but drilled out of place after bending.
G	·15	When the holes are fair and good in the circumferential seams, but drilled before bending.
H	·15	When the holes are fair and good in the circumferential seams, but punched after bending.
I	·2	When the holes are fair and good in the circumferential seams, but punched before bending.
J*	·2	When the holes are not fair and good in the circumferential seams.
K	·2	When double butt-straps are not fitted to the longitudinal seams, and said seams are lap and double-riveted.
L	·1	When double butt-straps are not fitted to the longitudinal seams and the said seams are lap and treble-riveted.
M	·3	When only single butt-straps are fitted to the longitudinal seams and the said seams are double-riveted.
N	·15	When only single butt-straps are fitted to the longitudinal seams and the said seams are treble-riveted.
O	1·0	When any description of joint in the longitudinal seams is single-riveted.
P	·1	When the circumferential seams are fitted with single butt-straps and are double-riveted.

* The allowance may be increased still further if the workmanship or material is very doubtful or very unsatisfactory.

TABLE GIVING THE CONSTANTS TO BE ADDED TO THE FACTOR OF SAFETY FOR CYLINDRICAL BOILERS (concluded).

Mark	Constants	Circumstances in which the Constants have to be added
Q	·2	When the circumferential seams are fitted with single butt-straps and are single-riveted.
R	·1	When the circumferential seams are fitted with double butt-straps and are single-riveted.
S	·1	When the circumferential seams are lap joints and are double-riveted.
T	·2	When the circumferential seams are lap joints and are single-riveted.
U	·25	When the circumferential seams are lap and the strakes or plates are not entirely under or over.
V	·3	When the boiler is of such a length as to fire from both ends, or is of unusual length, such as flue boilers, and the circumferential seams are fitted as described opposite P, R, and S; but when the circumferential seams are as described opposite Q and T, V ·3 will become V ·4.
W*	·4	When the seams are not properly crossed.
X*	·4	When the iron is in any way doubtful and the surveyor is not satisfied that it is of the best quality.
Y	1·65	When the boiler is not open to inspection during the whole period of its construction.

Strength of Joints in Cylindrical Boilers.

FORMULA.

P = percentage of strength of plate at joint as compared with the solid plate.

P′ = percentage of strength of rivets as compared with the solid plate.†

p = pitch of rivets. d = diameter of rivets.

a = area of rivets. n = number of rows of rivets.

t = thickness of plate.

$$P = \frac{(p-d) \times 100}{p} \qquad P' = \frac{(a \times n) \times 100}{p \times t}$$

Then take iron as equal to 47,000 lbs., and use the smallest of the two percentages as the strength of the joint, and adopt the factor of safety as found from the preceding table.

* The allowance may be increased still further if the workmanship or material is very doubtful or very unsatisfactory.

† If the rivets are exposed to double shear, multiply the percentage as found by 1·75. Maximum pitch of the rivets should not exceed 8½″, and if in any case the surveyor finds the pitch in excess of this, he should report to the Board of Trade.

Pressure on Safety Valves in Cylindrical Boilers.

FORMULA.

P = pressure to be allowed per square inch.

S = percentage of strength of joint.

D = inside diameter of boiler in inches.

t = thickness of plate. f = factor of safety.

$$P=\frac{(47000 \times S) \times 2t}{D \times f}$$

Plates, Butt Straps, Size of Rivets, &c., of Cylindrical Boilers.

Plates that are drilled in place *must* be taken apart and the burr taken off, and the holes slightly countersunk from the outside.

Butt straps *must* be cut from plates and *not* from bars, and must be of as good quality as the shell plates, and those for the longitudinal seams *must* be cut across the fibre. When the straps are drilled in place they should be taken apart, the burr taken off, and the hole slightly countersunk from the outside.

When single butt-straps are used they *must* be one-eighth thicker than the plates they cover. The diameter of the rivets *must* not be less than the thickness of the plates of which the shell is made, but it will be found when the plates are thin, or when lap joints or single butt-straps are adopted, that the diameter of the rivets should be in excess of the thickness of the plates.

Dished ends, unless of the thickness required for a flat end, should be stayed; but when they are theoretically equal to the pressure needed, when considered as portions of spheres, the stays, when solid, may have a stress of 14,000 lbs. per sq. inch of net section, but the stress should not exceed 10,000 lbs. when the stays have been welded or worked in the fire. If they are not theoretically equal to the pressure needed, they should be stayed as flat surfaces.

Hemispherical ends subjected to internal pressure may be taken as double that of a cylinder of the same diameter and thickness.

All manholes and openings must be stiffened with compensating rings of at least the same effective sectional area as the plates cut out, and in no case should the plate rings be less in thickness than the plates to which they are attached. The openings in the shells of cylindrical boilers should have their shorter axes placed longitudinal. It is very desirable that the compensating rings round openings in flat surfaces should be made of L or T iron.

STEAM PIPES.

Board of Trade Rules for the Diameter and Thickness of Steam Pipes.

(i.) For copper pipes when the joints are brazed,

$$P = \frac{6000 \times (T - \frac{1}{16})}{D}$$

where P = working pressure in lbs. per sq. inch.
T = thickness in inches.
D = inside diameter in inches.

When the pipes are solid drawn and not over 8 inches diameter substitute in the foregoing formula $\frac{1}{32}$ for $\frac{1}{16}$.

(ii.) For wrought-iron pipes made of good material and lap-welded,

$$P = \frac{6000 \times T}{D}.$$

This formula does not apply when the thickness is less than $\frac{1}{4}$ inch.

Note.—Feed-pipes should be made sufficient for a pressure 20 per cent. in excess of the boiler pressure.

Circular Furnaces.

The following formulæ may be used to determine the working pressure when the longitudinal joints are welded or made with a butt strap double riveted, or double butt straps single riveted:

P = working pressure per sq. inch.
L = length in feet.
T = thickness of plate in inches.
D = diameter in inches.

$$P = \frac{90000 \times T^2}{(L+1) \times D}.$$

Without the Board's special approval of the plans the pressure is in no case to exceed

$$\frac{9000 \times T}{D}.$$

The second formula limits the crushing stress on the material of 4,500 lbs. per sq. inch.

The length to be measured between the rings, if the furnace is made with rings.

If the longitudinal joints, instead of being butted, are lap-jointed in the ordinary way, and double riveted, then 75000 is to be used instead of 90000, excepting only where the lap is bevelled and so made as to give the flues the form of a *true* circle, when 80000 may be used.

When the material or the workmanship is not of the best quality, the constants given above must be reduced—that is to say, the 90000 will become 80000, the 80000 will become 70000, and the 70000 will become 60000.

One of the conditions of best workmanship must be that the joints are either double-riveted with single butt straps or single-riveted with double butt straps, and the holes drilled after the bending is done and when in place, and afterwards taken apart, the burr on the holes taken off, and the holes slightly countersunk from the outside.

Cylindrical Superheaters.

The strength of the joints and the factor of safety is found in a similar manner as for cylindrical boilers and steam receivers, but instead of using 47,000 lbs. as the tensile strength of the iron, 30,000 lbs. is adopted, unless, where the heat or flame impinges at or nearly at right angles to the plate, then 22,400 lbs. is substituted. When a superheater is constructed with a tube subject to external pressure, the working pressure should be ascertained by rules given for circular furnaces, but the constants should be reduced as 30 to 47.

In all cases the internal steam pipes should be so fitted that the steam in flowing to them will pass over all the plates exposed to the impact of heat or flame. Superheaters that can be shut off from the main boilers must be fitted with a Parliamentary safety valve of sufficient size, but the least size which will be passed without special written authority is 3 inches diameter.

The flat ends of all boilers, as far as the steam space extends, and the ends of superheaters, should be fitted with shield or baffle plates where exposed to the hot gases in the uptake.

IRON BOILERS.

Compressive Stress on Tube Plates should not be more than 9,000 lbs., which is that followed in the following formula—

$$\frac{(\mathrm{D}-d)\mathrm{T}\times 18000}{\mathrm{W}\times\mathrm{D}}.$$

D = least horizontal distance between centres of tubes in inches.

d = inside diameter of ordinary tubes in inches.

T = thickness of tube plate in inches.

W = extreme width of combustion box in inches from front of tube plate to back of fire-box, or distance between combustion-box tube plates when boiler is double-ended and the box common to the furnaces at both ends.

P = working pressure.

STEEL BOILERS.

Tests.—Test strips for tensile stress to be about 2″ wide, and the elongation 25 per cent. taken in a length of 10″, and not less than 18 per cent., but if the plates are annealed the elongation to be not less than 20 per cent. Bending test strips cut from furnaces, combustion boxes, 2″ broad and 10″ long, to be heated to a cherry red, cooled in water at about 80°, and bent until they break, or until the sides are parallel at a distance from each other of not more than three times the thickness of the plate. The tensile stress of the plates not exposed to flame to be not less than 27 tons, and should not exceed 32 tons per square inch of section, and 27 tons to be the stress used in the calculation for cylindrical shells; but for each ton the minimum tensile strength of the plate is above 27 tons, 1 ton may be added to the 27 used in the calculations, provided the surveyor witnesses the testing of all the plates. The tensile stress of furnace, flanging, and combustion box may range from 26 to 30 tons per square inch. The tensile strength of stay bars to be from 27 to 32 tons per square inch, with an elongation of about 25 per cent., and not less than 20 per cent. in a length of 10 inches. Solid steel screwed stays which have not been welded or otherwise worked after heating may be allowed a working stress of 9,000 lbs. per square inch of net section. Steel stays which have been welded or worked in the fire have been found to be unreliable.

The tensile strength of rivet bars to be from 26 to 30 tons per square inch, with an elongation of not less than 25 per cent. in a length of 10″. The tensile strength of the rivets should be from 27 to 32 tons per square inch, and the contraction of area about 60 per cent.

The Constants in the Board's Rules for Iron Boilers may be increased as follows:—The constants for flat surfaces, when they are supported by stays screwed into the plate and riveted, 10 per cent. The constants for flat surfaces, when they are supported by stays screwed into the plate and nutted, or when the stays are nutted in the steam space, 25 per cent. This is also applicable to the constants for flat surfaces stiffened by riveted washers or doubling strips and supported by nutted stays.

The constants for combustion box girders 10 per cent. The furnaces constants 10 per cent. when plain. When corrugated and machine made by Messrs. The Leeds Forge Co., of the Fox corrugated and Morison suspension types, or by Messrs. John Brown & Co., Sheffield, of the Purves ribbed and grooved type, and practically true circles, the working pressure is found by the following formula, provided that the plain parts at the ends do not exceed 9″ in length, and the plates are not less than $\frac{5}{16}$″ thick.

$$\frac{14000 \times T}{D} = P.$$

T = thickness in inches.

D = outside diameter in inches.

P = working pressure.

Compressive Stress on Tube Plates not more than 11,200 lbs., which is that used in the following formula:—

$$\frac{(D-d)T \times 22400}{W \times D} = P.$$

D = least horizontal distance between centre of tubes in inches.

d = inside diameter of ordinary tubes in inches.

T = thickness of tube plate in inches.

W = extreme width of combustion box in inches from front of tube plate to back of fire-box, or distance between combustion-box tube plates when boiler is double-ended and the box common to the furnaces at both ends.

P = working pressure.

Plate and Rivet Section.—When full allowance is wished, the rivet section, if iron in the longitudinal seams of cylindrical shells, should, when those seams are lapped, be at least $\frac{13}{8}$ times the net plate section, and if steel rivets are used their section should be at least $\frac{28}{23}$ of the net section of the plate if the tensile stress of the rivet is not less than 27 tons and not more than 32 tons per square inch. In calculating the working pressure, the percentage strength of iron rivets found should be divided by $\frac{13}{8}$, and in the case of steel rivets $\frac{28}{23}$, the results being the percentage required. When using the percentage strength of the plate 4·5 plus the additions suitable for the method of construction as by the Board's rules for iron boilers, may be used as the nominal factor of safety, but when using the percentage strength of the rivets, 4·5 may be used as the factor of safety.

Gauges, &c.

Each boiler must be fitted with a glass water-gauge, at least three test cocks, and steam gauge; boilers that fire both ends, and those of unusual width, must have water gauges and test cocks at each end or side, as the case may be. When a steamer has more than one boiler, each boiler must be treated as a separate one, and have all the requisite fittings.

Hydraulic Tests.

All new boilers, and boilers that have been taken out of ships for thorough repair, must be tested by hydraulic pressure up to

Safety Valve Areas.

Boiler Pressure	Area of Valve per Sq. Foot of Fire-grate	Boiler Pressure	Area of Valve per Sq. Foot of Fire-grate	Boiler Pressure	Area of Valve per Sq. Foot of Fire-grate
15	1·250	79	·398	143	·237
16	1·209	80	·394	144	·235
17	1·171	81	·390	145	·234
18	1·136	82	·386	146	·232
19	1·102	83	·382	147	·231
20	1·071	84	·378	148	·230
21	1·041	85	·375	149	·228
22	1·013	86	·371	150	·227
23	·986	87	·367	151	·225
24	·961	88	·364	152	·224
25	·937	89	·360	153	·223
26	·914	90	·357	154	·221
27	·892	91	·353	155	·220
28	·872	92	·350	156	·219
29	·852	93	·347	157	·218
30	·833	94	·344	158	·216
31	·815	95	·340	159	·215
32	·797	96	·337	160	·214
33	·781	97	·334	161	·213
34	·765	98	·331	162	·211
35	·750	99	·328	163	·210
36	·735	100	·326	164	·209
37	·721	101	·323	165	·208
38	·707	102	·320	166	·207
39	·694	103	·317	167	·206
40	·681	104	·315	168	·204
41	·669	105	·312	169	·203
42	·657	106	·309	170	·202
43	·646	107	·307	171	·201
44	·635	108	·304	172	·200
45	·625	109	·302	173	·199
46	·614	110	·300	174	·198
47	·604	111	·297	175	·197
48	·595	112	·295	176	·196
49	·585	113	·292	177	·195
50	·576	114	·290	178	·194
51	·568	115	·288	179	·193
52	·559	116	·286	180	·192
53	·551	117	·284	181	·191
54	·543	118	·281	182	·190
55	·535	119	·279	183	·189
56	·528	120	·277	184	·188
57	·520	121	·275	185	·187
58	·513	122	·273	186	·186
59	·506	123	·271	187	·185
60	·500	124	·269	188	·184
61	·493	125	·267	189	·183
62	·487	126	·265	190	·182
63	·480	127	·264	191	·181
64	·474	128	·262	192	·181
65	·468	129	·260	193	·180
66	·462	130	·258	194	·179
67	457	131	·256	195	·178
68	451	132	·255	196	·177
69	446	133	·253	197	·176
70	·441	134	·251	198	·176
71	·436	135	·250	199	·175
72	·431	136	·248	200	·174
73	·426	137	·246		
74	·421	138	·245		
75	·416	139	·243		
76	·412	140	·241		
77	·407	141	·240		
78	·403	142	·238		

at least double the working pressure that will be allowed previous to the boilers being replaced in position to test the workmanship, &c.; but the working pressure is to be determined by the stay power, thickness of plates, and strength of riveting, &c.

SAFETY VALVES.

Provisions of the Act as regards Safety Valves.

Every steamship of which a survey is required by the Act must be provided with a safety valve upon each boiler, so constructed as to be out of the control of the engineer when the steam is up; and if such valve is in addition to the ordinary valve, it shall be so constructed as to have an area not less, and a pressure not greater, than the area of and pressure on that valve.

Area of Safety Valves.

The area per square foot of fire-grate surface of the locked-up safety valve should not be less than that given in the following table opposite the boiler pressure intended, but in no case should the valves be less than 2 inches in diameter.

When the valves are of common description, and are made in accordance with the tables, it will be necessary to fit them with springs having great elasticity; and as boilers with forced draught may require valves considerably larger than those found by the tables, the design of the valves proposed for such boilers, together with the estimated coal consumption per square foot of fire-grate, should be submitted to the Board for consideration. To find the fire-grate area, the length of the grate to be measured from the inner edge of the dead plate to the front of the bridge, and the width from side to side of the furnace on the top of the bars at the middle of their length.

The safety valve to be fitted with lifting gear, so that two or more valves on any one boiler can be eased together without interfering with the valves on any other boiler. The lifting gear to be arranged so that it can be worked by hand either from the engine-room or stokehole; safety valves to have a lift equal to one-fourth their diameter.

Spring Safety Valves.

Spring safety valves may be fitted in passenger steamers instead of dead-weighted valves, provided that the following conditions are complied with:—

1. That at least two separate valves are fitted to each boiler.
2. That the valves are of the proper size.

3. That the spring and valve be so cased in that they cannot be tampered with.

4. That provision be made to prevent the valve flying off in case of the spring breaking.

5. That the requisite safety-valve area is cased in, in the usual manner of Government valves.

6. That screw lifting-gear be provided to ease all the valves, if necessary, when steam is up.

7. That the springs be protected from the steam and impurities issuing from the valves.

8. That when the valves are loaded by direct springs, the compressing screw abuts against a metal stop or washer when the load sanctioned by the surveyor is on the valve.

9. That the size of the steel of which the spring is made is found by the following formula:—

FORMULA.

D = diameter or side of square of the wire in inches.
d = diameter of the spring, from centre to centre of wire, in ins.
S = load on the spring in lbs.
k = constant = 8000 for round and 11000 for square steel.

$$D = \sqrt[3]{\frac{(S \times d)}{k}}$$

That the springs have a sufficient number of coils to allow a compression under the working load of at least $\frac{1}{4}$ diameter of the valve.

Note.—The accumulation of pressure should not exceed 10 per cent. of the loaded pressure.

MACHINERY.

Cocks, Valves, and Pipes communicating with Ship's Side.

All inlets or outlets in the bottom or side of a vessel, near to, at, or below the load water-line, must have cocks or valves fitted between the pipes and the ship's side or bottom. Such cocks or valves must be attached to the skin of the ship, and be so arranged that they can be easily and expeditiously opened or closed at any time.

All blow-off cocks and sea connections are to be fitted with a guard over the plug, with a feather-way in the same, and a key on the spanner, so that the spanner cannot be taken out unless the plug or cock is closed. One cock is to be fitted to the boiler, and another cock on the skin of the ship or on the side of the Kingston valve.

In all cases where pipes are so led or placed that water can run from the boiler or the sea into the bilge, either by accidentally or intentionally leaving a cock or valve open, they should be fitted with a non-return valve and a screw, not attached, but which will set the valve down in its seat when

necessary. The only exception to this is the firemen's ash cock, which must have a cock or valve on the ship's side and be above the stoke-hole plates.

The exhaust pipe for the donkey engine must not be led through the ship's side, but must be led on deck or into the main waste-steam pipe, and in all cases it should have a drain cock on it.

Spare Gear and Stores to be Carried.

Steamers coming in for survey under the Passenger Acts, and other steamers performing ocean voyages, must carry at least the following spare gear, which must have been fitted and tried in its place:—

1 pair of connecting-rod brasses.
1 air-pump bucket and rod with guide.
1 circulating-pump bucket and rod.
1 air-pump head-valve, seat, and guard.
1 set of india-rubber valves for air pumps.
1 circulating-pump head-valve, seat, and guard.
1 set of india-rubber valves for circulating pumps.
2 main bearing bolts and nuts.
2 connecting-rod bolts and nuts.
2 piston-rod bolts and nuts.
8 screw-shaft coupling bolts and nuts.
1 set of piston springs.
8 sets, if of india-rubber, or 1 set if of metal, of feed-pump valves and seats.
8 sets, if of india-rubber, or 1 set if of metal, of bilge-pump valves and seats.
Boiler tubes, 3 for each boiler.
100 iron assorted bolts, nuts, and washers screwed, but need not be turned.
12 brass bolts and nuts, assorted, turned, and fitted.
50 iron " " "
50 condenser tubes and 1 hydrometer.
100 sets of packing for condenser-tube ends, or an equivalent.
At least one spare spring of each size for escape valves.
1 set of water-gauge glasses.
$\frac{1}{10}$ the total number of fire bars necessary.
8 plates of iron, and 6 bars of iron assorted.
1 complete set of stocks, dies, and taps, suitable for the engines.
Ratchet braces and suitable drills.
1 copper or metal hammer and 1 smith's anvil.
1 screw jack and 1 fitter's vice.
Suitable blocks and tackling for lifting weights.
1 dozen files, assorted, and handles for the same.
1 set of drifts or expanders for boiler tubes.
1 set of safety-valve springs, if so fitted, for every four valves; if there are not four valves, then at least one set of springs must be carried.

And a set of engineer's tools suitable for the service, including hammers and chisel for vice and forge, solder and soldering-iron, sheets of tin and copper, spelter, muriatic acid or other equivalent, &c. &c.

Size of Shafts

Main and tunnel and propeller shafts should be of at *least* the diameter as found by the following formulæ:—

FORMULA FOR COMPOUND CONDENSING ENGINE WITH TWO CYLINDERS, WHEN THE CRANKS ARE NOT OVERHUNG.

S = diameter of shaft in inches.

d^2 = square of diameter of high-pressure cylinder in inches, or sum of squares of diameters when there are two or more high-pressure cylinders.

D^2 = square of diameter of low-pressure cylinder in inches, or sum of squares of diameters when there are two or more low-pressure cylinders.

P = *absolute* pressure in lbs. per square inch, that is, boiler pressure plus 15 lbs.

C = length of crank in inches.

k = constant from following table.

$$S = \sqrt[3]{\frac{C \times P \times D^2}{k\left(2 + \frac{D^2}{d^2}\right)}}. \qquad P = \frac{k \times S^3}{C \times D^2}\left(2 + \frac{D^2}{d^2}\right).$$

FORMULA FOR ORDINARY CONDENSING ENGINES WITH ONE, TWO, OR MORE CYLINDERS, WHEN THE CRANKS ARE NOT OVERHUNG.

S = diameter of shafts in inches.

D^2 = square of diameter of cylinder in inches, or sum of squares of diameters when there are two or more cylinders.

P = *absolute* pressure in lbs. per square inch.

C = length of crank in inches.

k = constant from following table.

$$S = \sqrt[3]{\frac{C \times P \times D^2}{3 \times k}}. \qquad P = \frac{3 \times k \times S^3}{C \times D^2}.$$

For Two Cranks Angle between Cranks	For Crank and Propeller Shafts *k* *		For Tunnel Shaft *k*
90°	For paddle engines of ordinary type, multiply constant of this column suitable for angle of crank by 1·4	1·047	1·221
100°		966	1·128
110°		904	1·055
120°		855	997
130°		817	953
140°		788	919
150°		766	894
160°		751	877
170°		743	867
180°		740	864
For Three Cranks 120°		1,110	1,295

* The constants in this column to be reduced by 15 per cent. when dealing with shafts for new vessels.

Stores to be Carried with Distilling Apparatus.

The following list of tools and material must be provided for distilling apparatus :—

1 set of stoking tools.
1 scaling tool.
1 spanner for boiler doors.
1 set of fire bars, suitable for boiler.
1 14-inch flat bastard file.
1 14-inch half-round file.
1 10-inch round file.
3 file handles.
2 hand cold chisels.
1 chipping hammer.
1 pair of efficient gas tongs.
1 soldering iron.
10 lbs. of solder.
2 lbs. of resin.
6 gauge glasses.
24 india-rubber gauge-glass washers.
30 bolts and nuts, assorted.
1 slide rod for donkey pump.
5 lbs. of spun yarn.
10 lbs. of cotton waste.
1 deal box with lock complete.
2 gallons of machinery oil.
1 can for "
1 oil-feeder.
1 small bench vice.
1 ratchet brace.
4 drills, assorted.
1 set of dies and taps suitable for the bolts.
2 glass salinometers.
1 hydrometer and pot.
1 shifting spanner.
1 lamp for engineer.

Animal charcoal sufficient to charge the filter at least twice.

And other articles that the particular distiller and boiler supplied may, in the surveyor's judgment, require.

BOARD OF TRADE REGULATIONS FOR SHIPS.

PASSENGER CERTIFICATES.

THESE certificates are granted as follows:—

Form survey 1 (sea-going) is given for foreign-going steamers.

Form survey 2 (sea-going) is given for home trade passenger steamers.

Form survey 3 (excursion) is given for steamers plying along the coast during daylight between any of the places mentioned in column 1 of the following table of limits and the places set opposite to them in column 4 of the same table.

Form survey 4 (river) is given for steamers plying between any of the places mentioned in column 1 of the table and the places set opposite to them in column 3.

Form survey 5 (rivers and lakes) is given for steamers plying in the smooth-water limits lying between the places mentioned in column 1 and the places set opposite to them in column 2.

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES.

COL. 1. Name of Port	Form Survey 5. COL. 2. Smooth Water Limits	Form Survey 4. COL. 3. Partially Smooth Water Limits	Form Survey 3. COL. 4. Excursion Limits
ABERDEEN .	Inside the Harbour	Nil . . .	Peterhead or Montrose
BRISTOL .	Within a line from Avonmouth Pier to Wharf Point	*In winter*, nil. *In summer*, within a line from Lavernock Point to the Flatholm, thence to the Steepholm, thence to Bream Down	Ilfracombe or Swansea
BOWNESS .	Anywhere on the Lakes	Nil . . .	Nil
BOSTON .	Inside the New Cut	Nil . . .	Cromer or Hull
BERWICK-ON-TWEED	Spittal Point.	Nil . . .	North Berwick or Newcastle
BELFAST .	Within a line from Holywood to Macedon Point	*In summer*, within a line from Carrickfergus to Bangor; *in winter*, nil	Rathlin Island or Killough
BARROW .	Inside Walney Island	Nil . . .	Liverpool or Whitehaven

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES—*continued.*

COL. 1. Name of Port	Form Survey 5. COL. 2. Smooth Water Limits	Form Survey 4. COL. 3. Partially Smooth Water Limits	Form Survey 3. COL. 4. Excursion Limits
CARLISLE .	Above Port Carlisle	Within a line from Southerness to Silloth	Whitehaven or Port Whithorn
CARDIFF ..	Within a line from Low-water Pier Head to the Lifeboat House near Penarth Dock entrance	*In winter*, nil. *In summer*, within a line from Lavernock Point to the Flatholm, thence to the Steepholm, thence to Bream Down	Tenby or Ilfracombe
CARNARVON.	Menai Straits to Aber Menai or Beaumaris	Menai Straits from Carnarvon Bar to Puffin Island	Liverpool or Portmadoc or round the island of Anglesea
CONWAY .	Within a line from Mussel Hill to Trevlyd Point	Nil	Same as Carnarvon
CORK .	Within a line from Camden to Carlisle Forts	Nil	Dungarvan or Galley Head
CAMPBELTOWN	Inside the Harbour, but not outside Davaar Island	Nil	Glasgow only
DARTMOUTH	River Dart .	Nil	Plymouth or Weymouth
DOVER .	Nil . .	Nil	Newhaven or Sheerness
DUNDEE .	Within a line from Dundee and Newport Ferries	Within a line from Broughty Castle to Tayport	Montrose or Leith
DUBLIN .	Inside the Pier Heads	*In summer*, from Dalkey Island to Bailey Point. *In winter*, nil	Drogheda or Arklow

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES—*continued.*

COL. 1. Name of Port	Form Survey 5. COL. 2. Smooth Water Limits	Form Survey 4. COL. 3. Partially Smooth Water Limits	Form Survey 3. COL. 4. Excursion Limits
DOUGLAS (I.M.)	From Battery Pier to Victoria Pier	Nil . . .	Round the island
FLEETWOOD.	From Low Light to Knotend Pier	Nil . . .	Whitehaven or Liverpool
FALMOUTH .	Zoze Point to Pendennis Point . .	Nil . . .	Start Point or Penzance
FOLKESTONE	Nil . .	Nil . . .	Newhaven or Sheerness
GALWAY .	Lough Corrib	Black Rock Beacon to Kilcolgan Point	Kilkieran or Liscannon Bays
GLOUCESTER	River Severn or Avon to Sharpness Point *viâ* Gloucester Canal	*In winter*, nil. *In summer*, Lavernock Point to Flatholm, thence to Steepholm, thence to Bream Down	Watchet or Barry Docks
GLASGOW .	*In winter*, from Clock Lighthouse to Dunoon Pier. *In summer*, from Bogary Point, Isle of Bute, to Skelmorlie Castle and Ardlamont Point, inside the Kyles of Bute	From Skipness to Fairlie Head, round the Isle of Bute	Stanraer or Campbeltown
GRIMSBY .	Nil . .	*In winter*, nil. *In summer*, from Cleethorpes Pier to Patrington Church	Lynn or Scarborough

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES—*continued.*

Col. 1. Name of Port	Form Survey 5. Col. 2. Smooth Water Limits	Form Survey 4. Col. 3. Partially Smooth Water Limits	Form Survey 3. Col. 4. Excursion Limits
GOOLE . .	*In winter*, from Whiffenness to Brough. *In summer*, above Hull and New Holland	*In winter*, from New Holland to Paull. *In summer*, same as Grimsby	Lynn or Scarborough
HULL . .	*See* Goole .	*See* Goole . .	*See* Goole
INVERNESS .	Fort George to Chanonry Point to Fort William	Nil . . .	Lossiemouth or Dunrobin
IPSWICH .	Inside Languard Fort	From Walton-on-Naze to Languard Fort	London or Yarmouth
LANCASTER .	From Sunderland Point to Chapel Point	Nil . . .	Whitehaven or Liverpool
LEITH . .	Nil . .	From Kircaldy to Portobello	Berwick-on-Tweed or Dundee
LIMERICK .	Foynes . .	From Scattery Lighthouse to Carrig Island	Loop Head or Kilmore Head
LITTLE-HAMPTON	Above Littlehampton Pier	Nil . . .	Poole or Rye
LONDON-DERRY	From Magilligan Point to Greencastle	Nil . . .	Buncrana in Lough Swilly or Rathlin Island
LOWESTOFT .	Inside Lowestoft Pier to Norwich	From S.W. Barnard Buoy to North Cockle Buoy inside the banks	Cromer or Walton-on-Naze
LIVERPOOL .	The Rock Lighthouse	*In winter*, nil. *In summer*, from Formby Point to Hilborough Point	Barrow, Holyhead, or Carnarvon
LONDON .	Gravesend .	From Clacton Pier to Herne Bay Pier	Dover or Harwich

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES—*continued.*

Col. 1. Name of Port	Form Survey 5. Col. 2. Smooth Water Limits	Form Survey 4. Col. 3. Partially Smooth Water Limits	Form Survey 3. Col. 4. Excursion Limits
MILFORD .	From Hubberston Beach to Angle Point	South Hook Point to Thorn Island	Swansea or Cardigan
NORWICH .	Inside the Piers	From S.W. Barnard Buoy to North Cockle Buoy	Cromer or Walton-on-Naze
NEATH .	Inside the Bar	Nil . . .	Barnstaple or Milford
NEWCASTLE, NORTH AND SOUTH SHIELDS	Inside the Tyne Pier Heads	Nil . . .	Berwick-on-Tweed or Scarborough
PADSTOW .	Padstow Harbour, above a line from Gun Point to Brae Hill	Within a line from Stepper Point to Trebetherick Point	St. Ives or Barnstaple
PENZANCE .	Nil . .	Nil . . .	Falmouth or St. Ives
PORTSMOUTH	Inside Portsmouth Harbour	St. Helens and the Needles, within the Isle of Wight, and to Langston Harbour	Newhaven or Weymouth
PRESTON .	Lytham . .	Within a line from Southport or Blackpool, inside the banks	Llandudno or Barrow
POOLE . .	Inside the Harbour	Nil . . .	Weymouth or the Nab
PLYMOUTH .	Inside of Drake's Island to Mount Batten Pier	From Causand to Breakwater, and to Staddon Pier	Exeter or the Lizard
ROCHESTER .	Sheerness and Whitstable, inside Sheppey	Clacton Pier to Herne Bay Pier	Dover or Harwich
SWANSEA .	Nil . .	Nil . . .	Barnstaple or Milford

TABLE OF PLYING LIMITS FOR EXCURSION, RIVER, AND PARTIALLY SMOOTH WATER CERTIFICATES—*concluded.*

Col. 1. Name of Port	Form Survey 5. Col. 2. Smooth Water Limits	Form Survey 4. Col. 3. Partially Smooth Water Limits	Form Survey 3. Col. 4. Excursion Limits
SUNDERLAND	Inside the Sunderland Pier Heads	Nil . . .	Berwick-on-Tweed or Scarborough
STOCKTON .	Fourth Bay .	Nil . . .	Amble or Bridlington
SOUTHAMPTON	Calshot Castle	Same as Portsmouth	Same as Portsmouth
SCARBOROUGH	Nil . .	Nil . . .	Newcastle or Hull
TEIGNMOUTH	Within the Harbour	Nil . . .	Weymouth or Plymouth
WATERFORD	Passage. .	*In summer*, from Dunmore to Hook Point; *in winter*, from Geneva Barrack to Duncannon Light	Youghal or Wexford
WIGTOWN .	Nil . .	Nil . . .	Stanraer or Dumfries
WISBEACH .	Inside Wisbeach Cut	Nil . . .	Cromer or Hull
WEYMOUTH .	Nil . .	Portland Harbour	Portsmouth or the Start
WHITBY .	Inside the Whitby Pier Heads	Nil . . .	Bridlington or Newcastle

EXAMINATION OF HULLS.

Passenger vessels are to be surveyed once a year.

New steamships are to be surveyed before the hull is complete, and before the paint and cement are put on, as well as when complete.

An efficient and water-tight engine-room and stoke-hole bulkhead, as well as a collision water-tight bulkhead, and an after water-tight compartment to enclose the stern-tube of each screw shaft, should be fitted in all sea-going steamers.

Screw tunnels of all iron passenger steam vessels should be made of iron and made water-tight.

A water-tight door should be fitted at the fore end of the tunnel, arrangements being made so that it can be opened from the upper or main deck; and if there are man-holes in the floor they must be made water-tight, and proper arrangements made so as to let the water off the floor of the tunnel.

The maximum period for which a steamer's certificate of registry is granted is 12 months.

Boats and Life-saving Appliances.

Table C.

Gross tonnage 1	Minimum number of boats to be placed under davits 2	Total minimum cubic contents of boats to be placed under davits L.×B.×D.×·6 3
10,000 and upwards	16	5,500
9,000 and upwards	14	5,250
8,500 and under 9,000	14	5,100
8,000 ,, 8,500	14	5,000
7,750 ,, 8,000	12	4,700
7,500 ,, 7,750	12	4,600
7,250 ,, 7,500	12	4,500
7,000 ,, 7,250	12	4,400
6,750 ,, 7,000	12	4,300
6,500 ,, 6,750	12	4,200
6,250 ,, 6,500	12	4,100
6,000 ,, 6,250	12	4,000
5,750 ,, 6,000	10	3,700
5,500 ,, 5,750	10	3,600
5,250 ,, 5,500	10	3,500
5,000 ,, 5,250	10	3,400
4,750 ,, 5,000	10	3,300
4,500 ,, 4,750	8	2,900
4,250 ,, 4,500	8	2,900
4,000 ,, 4,250	8	2,800
3,750 ,, 4,000	8	2,700
3,500 ,, 3,750	8	2,600
3,250 ,, 3,500	8	2,500
3,000 ,, 3,250	8	2,400
2,750 ,, 3,000	6	2,100
2,500 ,, 2,750	6	2,050
2,250 ,, 2,500	6	2,000
2,000 ,, 2,250	6	1,900
1,750 ,, 2,000	6	1,800
1,500 ,, 1,750	6	1,700
1,250 ,, 1,500	6	1,500
1,000 ,, 1,250	4	1,200
900 ,, 1,000	4	1,000
800 ,, 900	4	900
700 ,, 800	4	800
600 ,, 700	3	700
500 ,, 600	3	600
400 ,, 500	2	400
300 ,, 400	2	350
200 ,, 300	2	300
100 ,, 200	2	250

Rules and Table for Steamships carrying Emigrant Passengers, or Foreign-going Steamships having Passenger Certificates.—Half the number of boats placed under davits shall be boats of section A or section B. The remaining boats may conform to section C or section D; not more than two boats shall be of section D.

If the boats placed under davits do not furnish sufficient accommodation for all persons on board, then additional wood, metal, collapsible or other boats or life-rafts shall be carried. One of these boats may be a steam launch; in that case the space occupied by the engines and boilers is not to be included in the estimated cubic capacity of the boat. Such additional boats or raft shall be of such carrying capacity that they and the other boats provide, in vessels of 5,000 tons gross and upwards, three-fourths, and in vessels of less than 5,000 tons gross, one-half, more than the minimum cubic contents required by column 3 of table C. For this purpose 3 cubic feet of air-case in the life-raft is to be estimated as 10 cubic feet of internal capacity. Ships of this class shall carry not less than one life-buoy for every boat placed under davits. They shall also carry life-belts, so that there may be at least one for each person on board the ship.

Steamships carrying Passengers anywhere within the Home Trade Limits.—To be as above; but if it is not practicable for any ship of this class to carry all the additional boats or life-rafts, the deficiency may be made up by the supply of an equivalent number of buoyant deck-seats; they shall carry not less than six approved life-buoys; they shall also carry life-belts, so that there may be at least one for each person on board the ship.

Rules for Sailing Ships carrying Emigrant Passengers, or Foreign-going Sailing Ships carrying Passengers.—They shall carry boats in accordance with the table C. If the boats do not furnish sufficient accommodation for all persons on board the ship, life-saving appliances shall be supplied as above, life-belts for each person on board, and also one life-buoy for each boat.

Rules for Foreign-going Sailing Ships not carrying Passengers.—Ships of this class shall carry a boat or boats of sections A or B sufficient for all the persons on board, and in addition thereto one good serviceable boat of section D; they shall carry life-belts for each person on board, and one life-buoy for each boat.

Rules for Foreign-going Steamships not carrying Passengers.—Ships of this class shall carry on one side a boat of sections A or B, and on the other a boat of sections A or B or C, so that the boats on each side of the ship shall be sufficient to accommodate all persons on board; they shall carry life-belts for every person on board, and not less than six life-buoys.

Rules for Steamships not carrying Passengers anywhere within the Home Trade Limits.—Ships of this class shall carry on each side at least one boat of sections A or B or C, so that the boats on each side of the ship shall be sufficient to accommodate all persons on board. They shall carry life-belts, so that there may be one for each person on board the ship. They shall carry not less than four approved life-buoys.

Rules for Sailing Ships in the same Trades not carrying Passengers.—Ships of this class shall carry a boat or boats sufficient for all persons on board; they shall carry a life-belt for each person on board, and at least two life-buoys.

Rules for Steamships carrying Passengers along the Coasts of the United Kingdom, between Great Britain and Ireland, or between Great Britain and Ireland and the Isle of Man.—Ships of this class shall carry boats as required by the table. Not less than half the number of boats placed under davits having at least half the cubic capacity required by the table, shall be of sections A or B. The remainder may be of section C or section D; but not more than two boats shall be of section D. If the boats do not furnish sufficient accommodation for all on board, then additional boats or life-rafts, or buoyant deck-seats, shall be carried; of at least such cubical capacity that they and the other boats provide together one-half more than the minimum cubic contents provided by column 3 of the table. For this purpose 3 cubic feet of air-case in the life-raft is to be estimated as 10 cubic feet of internal capacity. They shall also carry life-belts, at least one for each person on board the ship, and at least one life-buoy for each boat carried by the ship, but in no case shall less than six life-buoys be provided.

Rules for Steamships carrying Passengers on Short Excursions or Pleasure Trips to Sea or in Estuaries or Mouths of Rivers.—Ships of this class shall carry at least two boats of sections A or B or C, placed under davits; they shall also carry other boats, buoyant apparatus, and (or) life-belts sufficient with the other boats to keep afloat all the persons on board the ship; at least four life-buoys shall be carried.

Rules for Steamships carrying Passengers on Rivers and (or) Lakes, but not going to Sea or into Rough Waters.—Ships of this class shall carry one boat; they shall also carry buoyant apparatus or life-belts and life-buoys at least sufficient together with the boat to keep afloat all persons carried on board; at least four life-buoys shall be carried.

Note.—A discretion may be exercised by the Board of Trade to relieve steam-launches, steamers plying in narrow waters, and ferry boats from the operation of the whole or part of the rules for this class.

General Rules respecting Life-saving Appliances.—Section A to be a life-boat of whale-boat form, having for every 10 cubic feet of her capacity at least 1 cubic foot of strong and serviceable enclosed air-tight compartments, so constructed that water cannot find its way into them.

Section B to be a life-boat of whale-back form, having inside and outside a buoyancy apparatus together equal in efficiency to the buoyancy apparatus provided for a boat of section A. At least one-half of the buoyancy apparatus must be attached to the outside of the boat.

Section C to be a life-boat having some buoyancy apparatus attached to the inside and (or) outside of the boat equal in efficiency to one-half of the buoyancy apparatus provided for a boat of sections A or B; at least one-half of the buoyancy apparatus must be attached to the outside of the boat.

Section D to be a properly constructed boat of wood or metal. Cubic capacity to be ascertained (as in measuring ships for tonnage capacity) by Simpson's rules; but the following simple plan, which is approximately accurate, may be adopted: Measure the length and breadth outside and the depth inside, multiply them together and by ·6; the product is the capacity of the boat in cubic feet. If the oars are pulled in rowlocks, the bottom of the rowlock is to be considered the gunwale of the boat for ascertaining her depth. The number of persons a boat of section A may carry shall be the number of cubic feet ascertained as in rule divided by 10; the number of persons a boat of sections B, C, D may carry shall be the number of cubic feet ascertained as in rule divided by 8.

Equipments for Collapsible or other Boats and for Life-rafts.—With the full single-banked complement of oars, and two spare oars; with two plugs for each plug-hole, attached with lanyards or chains, and one set and a half of thole pin or crutches, attached to the boat by sound lanyards; with a sea anchor, a baler, a rudder and tiller, or yoke and yoke-lines, a painter of sufficient length, and a boat-hook. The rudder and baler to be attached to the boat by sufficiently long lanyards and kept ready for use, or a steering oar may be provided instead. A vessel to be kept filled with fresh water shall be provided for each boat; life-rafts shall be fully provided with a suitable equipment. Each boat of sections A and B, in addition to being provided with all the requisites laid down above, shall be equipped as follows, but not more than four boats require to have this outfit: With two hatchets or tomahawks; with a mast or masts, and with at least one good sail, and proper gear for each; with a line becketed round the outside of the boat and securely made fast; with an efficient compass; with one gallon of vegetable

or animal oil and a vessel for distributing it in the water in rough weather; with a lantern trimmed, with oil sufficient to burn eight hours.

Number of persons for life-rafts.—There shall be at least three cubic feet of enclosed air-tight compartments for every person carried. To be marked to indicate the number of adult persons it can carry. Buoyant apparatus shall not require to be inflated before use, and is to be marked to indicate the number of persons for whom it is sufficient. Life-belts to be capable of floating in the water for 24 hours with 15 lbs. of iron suspended from them. Life-buoy to be capable of floating in the water for at least 24 hours with 32 lbs. of iron suspended from it; it can be built of solid cork or any other approved material; but must not be stuffed with rushes, cork shavings, or any other shavings or loose material; and should not require inflation before use. All life-buoys and life-belts to be so placed as to be readily accessible to all persons on board.

Pumps, Sluice Valves, Steering Gear, etc.

There must be in each compartment a pump of sufficient size which can be worked from the upper deck.

There must be a valve or cock fitted at the bottom of each water-tight bulkhead, which can be opened from the upper deck, and also a sounding tube to each compartment.

Pipes connected with pumps, worked by the engines, are also to be carried through the bulkheads into the compartments fore and aft of the engine room; so that each compartment can be pumped out separately by the engines as well as by the deck pumps.

A spare tiller, relieving tackle, &c., should be carried in all sea-going steamers.

A deep-sea lead-line of at least 120 fathoms, a lead of at least 28 lbs. weight and a suitable reel, together with at least two hand lead-lines of 25 fathoms each, and leads of at least 7 lbs. each, should be supplied to all foreign-going steamers.

In home-trade steamers two hand lead-lines of 25 fathoms each, and leads of 7 lbs. each, must be supplied.

For a first-class certificate of registry (i.e. 12 months) double the number of leads and lines must be supplied.

Lead lines are usually marked as follows:—

At 2	fathoms	a piece of leather split into two strips.	
„ 3	„	„ „ „	three strips.
„ 5	„	„	white bunting.
„ 7	„	„	red bunting.
„ 10	„	„	leather with a hole.
„ 13	„	„	blue bunting.
„ 15	„	„	white bunting.
„ 17	„	„	red bunting.
„ 20	„	a strand with two knots tied in it.	

Distress Signals.

The signals required are 12 blue lights; 2 storm or danger signal lights and six smaller lights of the same description with means of attaching them to life-buoys; 12 rockets, each containing 16 ozs. of composition, and one gun of at least 3½ ins. the bore, or one mortar of 5½ ins., with ammunition for 12 charges, or, in the case of foreign sea-going passenger ships, 24 charges. Each charge must contain 16 ozs. of pebble or bean powder in a flannel bag. An air-tight copper magazine, rammers, sponges, wads, priming wires, friction tubes, powder flasks, with fine powder for priming, and means for firing and withdrawing charges should be provided.

Fire Hose.

A fire hose adapted for extinguishing fire in any part of the ship, and capable of being connected with the engines of the ship, or with the donkey engine if it can be worked from the main boiler, should be supplied.

Passenger Accommodation.

Passengers in Foreign-going Steamers.

The upper weather deck, and the upper surface of the poop, forecastle, and spar deck, are never to be included in the measurements for passengers; nor are the poop, round house, or deck house to be measured for passengers, unless they form part of the permanent structure of the vessel.

Foreign-going steamships carrying passengers are to be measured as follows:—

Saloon or 1st Class.—The number of fixed berths or sofas that are fitted determine the number of passengers to be allowed.

2nd Class.—The number is determined in the same way as the 1st class.

3rd Class.—The number may be determined in like manner if berths are fitted; if not, the net area of the deck, multiplied by the height between decks and the product divided by 72, gives the number to be allowed. The breadth of the deck is taken inside the water-way, or at the greatest tumble-home of the side, if there is any.

When cargo, stores, &c., are carried in the space measured for passengers, one passenger is to be deducted for every 12 superficial feet of deck space so occupied.

Passengers in Home-Trade Sea-going Steamers.

Fore-cabin passengers include all passengers except those entered as after-cabin or saloon passengers in the way bill.

The number of passengers allowed to be carried in sea-going home-trade steamers is ascertained as follows:—

The clear area of the deck in square feet is divided by nine; the quotient is the number allowed to be carried on deck. The main deck and the deck beneath are to be measured for passengers; and, in addition, all spaces included on the upper surface of quarter decks and poops are to be measured, provided the ship is stable enough and the sides efficiently protected by bulwarks.

The breadths of the deck are taken from inside the gutter water-way, or the inside edge of the raised covering-board, or inside edge of the rail, if the bulwarks tumble home farther than the inside edge of the water-way or covering-board.

The aggregate number of passengers, other than saloon or first-class passengers, is to be limited to six times the number for which there is a clear sheltered space for the voyage.

The clear area of deck in such spaces is to be reckoned at 9 square feet per passenger.

Where cargo, cattle, &c., are carried in the space measured for passengers in home-trade passenger steamers, the following deductions are to be made:—

For every square yard of space measured for passengers occupied by cattle or other animals, or by cargo or other articles, one passenger is to be deducted.

The number of passengers to be carried in the after-cabins is determined by the number of berths, or sofas, properly constructed for sleeping berths, provided there are 72 cubic feet of space for each passenger berthed in each state-room or cabin. The floor of state-rooms is never to be measured, but if the owner wishes to include in the measurements so much of the floor of the after saloon as is not covered by tables, &c., then that space may be measured instead of the upper surface of the poop or quarter deck overhead.

For the total number of cabin passengers so accommodated below there shall be reserved on deck or provided on a bridge deck or other suitable place, promenade, or airing space at the rate of 3 square feet per passenger, and this space shall not be counted or included in the area available for deck or any other passengers.

The number of fore-cabin passengers is obtained in the same way as the after-cabin number. The total number of passengers must not exceed the number denoting the gross register tonnage of the vessel.

All passenger accommodation should be properly ventilated

and lighted both by day and by night, and proper means of ingress and egress provided.

Passengers in Excursion Steamers.

For steamers used in excursions the rules for calculating the number of passengers are the same as in sea-going home-trade steamers, except that if application is made for an excursion certificate for short distances along the coast during daylight, the number, originally calculated at 9 superficial feet to each passenger, should it exceed the gross tonnage of the vessel, need not be diminished so as to bring it down to that number.

Where cargo, cattle, &c., are carried in the space measured for passengers in excursion steamers, one passenger is to be deducted for every square yard of space, measured for passengers, occupied by cattle, cargo, &c.

Passengers in River Steamers.

The measurements are to be made in the same manner as in home-trade sea-going steamers, except that one saloon only is to be included.

There will be no distinction between fore- and after-cabin passengers.

River steamers are divided into those which ply on waters part of which only are smooth, and those which ply exclusively on smooth water.

Taking this division—

For steamers which ply in partially smooth water, divide the number of superficial feet on deck, obtained as before, by six, and the clear space in the saloon by nine, and the sum of these quotients will be the number of passengers allowed.

In the last-mentioned class of steamers one and a half passenger is to be deducted for every square yard of space measured for passengers occupied by cattle, cargo, &c.

Between October 31 and April 1 the number of passengers which, according to the preceding rules, is allowed to be carried other than in cabins or saloons during summer is to be reduced by one-third.

These vessels are to be provided with a suitable anchor and cable, and a compass properly adjusted, and life-saving appliances similar to those carried by steamships on short excursions or pleasure trips to sea.

For smooth-water steamers divide the number of superficial feet on deck, obtained as before, by three, and the clear space in the saloon by nine, and the sum of these quotients is the number of passengers allowed.

Three passengers are to be deducted for every square yard of space measured for passengers occupied by cattle, cargo, &c.

No reduction to be made in winter months.

These vessels are to have a suitable anchor and cable.

Crew Space.

Every space occupied by the crew shall contain 72 cubic feet, and 12 superficial feet of surface for each seaman.

For every 20 men there should be two privies.

In measuring the clear area of deck in crew space, beds, bunks, or sleeping berths are not to be deducted as encumbrances, but in cabins there should not be less than 12 square feet per man exclusive of the bunk.

To compute the cubic capacity of the crew space, multiply the clear area of the floor space by the height from deck to deck at the middle line; the product will be the cubic capacity of the crew space. Divide the cubic capacity thus obtained by 72, and the quotient will be the number of men the place is to accommodate, provided that there is sufficient area of deck, as before computed.

Under the Merchant Shipping Act of 1894 the tonnage of all the places for the berthing of seamen and apprentices, and appropriated to their use, may be deducted from the register tonnage of the ship, provided that the number the crew space will accommodate is cut in or painted on or over the door or hatchway leading to such place; and also cut in on one of the beams in the inside of such crew space.

Minimum Dimensions of Ships' Lanterns.

The width of the back and side must not be less than 9 ins., and their height not less than 11 ins. If used as a side light the lens should be an arc of a circle, whose height should not be less than the length of its radius; and should embrace an angle of at least 120°.

LLOYD'S RULES FOR NEW BOILERS.

The Strength of Circular Shells of Iron Boilers.

$$\frac{C \times T \times B}{D} = \text{working pressure.}$$

Where C = coefficient as per following table.

T = thickness of plate in inches.

D = mean diameter of shell in inches.

B = percentage of strength of joint, found as follows, the least percentage to be taken :—

For plate at joint $B = \frac{p-d}{p} \times 100.$

For rivets at joint $B = \frac{n \times a}{p \times T} \times 100$, with iron rivets in iron plates with punched holes.

$B = \frac{n \times a}{p \times T} \times 90$, with iron rivets in iron plates with drilled holes.

(In cases of rivets being in double shear, 1·75*a* is to be used instead of *a*.)

Where p = pitch of rivets.

d = diameter of rivets.

a = sectional area of rivets.

n = number of rows of rivets.

TABLE OF COEFFICIENTS.—IRON BOILERS.			
Description of Longitudinal Joint	For Plates ½″ thick and under	For Plates ½″ thick and above ½″	For Plates above ¾″ thick
Lap joint, punched holes	155	165	170
„ drilled „	170	180	190
Double butt strap joint, punched holes . .	170	180	190
Double butt strap joint, drilled holes . .	180	190	200

Note.—The inside butt strap to be at least ⅝ of the strength of the longitudinal joint.

The Strength of Circular Shells of Steel Boilers.

$$\frac{C \times (T-2) \times B}{D} = \text{working pressure.}$$

Where D = mean diameter of shell in inches.

T = thickness of plate in sixteenths of an inch.

C = 21 when the longitudinal seams are fitted with double butt straps of equal width.

C = 20·25 when they are fitted with double butt straps of unequal width, only covering on one side the reduced section of plate at the outer line of rivets.

C = 19·5 when the longitudinal seams are lap joints. If the minimum strength of shell plates is 28 or 29 tons per square inch instead of 27, these values of C may be correspondingly increased.

B = the least percentage of strength of longitudinal joint found as follows:—

For plate at joint $B = \dfrac{p-d}{p} \times 100.$

For rivets at joint $B = \dfrac{n \times a}{p \times t} \times 85$ where steel rivets are used.

$B = \dfrac{n \times a}{p \times t} \times 70$ where iron rivets are used.

Where p = pitch of rivets in inches.

t = thickness of plate in inches.

d = diameter of rivet holes in inches.

n = number of rivets used per pitch in the longitudinal joint.

a = sectional area of rivet in square inches.

In case of rivets of double shear $1{\cdot}75a$ is to be used instead of a.

Note.—The inside butt strap to be of at least $\frac{3}{4}$ of the strength of the longitudinal joint.

Note.—For the shell plates of superheaters or steam chests enclosed in the uptakes or exposed to the direct action of the flame the coefficients should be $\frac{2}{3}$ of those given in the above tables.

The Strength of Stays supporting Flat Surfaces.

Iron Stays.—For stays not exceeding $1\frac{1}{2}''$ smallest diameter, and for all stays which are welded, 6,000 lbs. per square inch; for unwelded stays above $1\frac{1}{2}''$ smallest diameter, 7,500 lbs. per square inch.

Steel Stays.—For screw stays not exceeding $1\frac{1}{2}''$ smallest diameter, 8,000 lbs. per square inch; for screw stays above $1\frac{1}{2}''$ smallest diameter, 9,000 lbs. per square inch. For other stays not exceeding $1\frac{1}{2}''$ smallest diameter, 9,000 lbs. per square inch, and for stays exceeding $1\frac{1}{2}''$ smallest diameter, 10,000 lbs. per square inch. No steel stays are to be welded.

Stay Tubes.—The stress is not to exceed 7,500 lbs. per square inch.

The Strength of Flat Plates supported by Stays.

$$\frac{C \times T^2}{P^2} = \text{working pressure in lbs. per sq. inch.}$$

Where T = thickness of plate in sixteenths of an inch.

P = greatest pitch in inches.

C = 90 for iron or steel plates $\frac{7}{16}$ thick and under fitted with screw stays with riveted heads.

C = 100 for iron or steel plates above $\frac{7}{16}$ thick fitted with screw stays with riveted heads.

C = 110 for iron or steel plates $\frac{7}{16}$ thick and under fitted with stays and nuts.

C = 120 for iron plates above $\frac{7}{16}$ thick, and for steel plates above $\frac{7}{16}$ and under $\frac{9}{16}$ thick, fitted with screw stays and nuts.

C = 135 for steel plates $\frac{9}{16}$ thick and above fitted with screw stays and nuts.

C = 140 for iron plates fitted with stays and double nuts.

C = 150 for iron plates fitted with stays with double nuts and washers outside the plates, of at least $\frac{1}{3}$ of the pitch in diameter and $\frac{1}{2}$ the thickness of the plates.

C = 160 for iron plates fitted with stays with double nuts and washers riveted to the outside of the plates, of at least $\frac{2}{5}$ of the pitch in diameter and $\frac{1}{2}$ the thickness of the plates.

C = 175 for iron plates fitted with stays with double nuts and washers riveted to the outside of the plates, when the washers are at least $\frac{2}{3}$ of the pitch in diameter and of the same thickness as the plates.

For iron plates fitted with stays with double nuts and doubling strips riveted to the outside of the plates, of the same thickness as the plates, and of a width equal to $\frac{2}{3}$ the distance between the rows of stays, C may be taken as 175 if P is taken to be the distance between the rows, and 190 when P is taken to be the pitch between the stays in the rows.

For steel plates, other than those for combustion-chambers, the values of C may be increased as follows:—

C = 140	increased to	175
150	,,	185
160	,,	200
175	,,	220
190	,,	240

If flat plates are strengthened with doubling plates securely

riveted to them, having a thickness of not less than $\frac{2}{3}$ of that of the plates, the strength to be taken from

$$\frac{\text{C} \times \left(\text{T} + \dfrac{t}{2}\right)^2}{\text{P}^2} = \text{working pressure in lbs. per sq. inch;}$$

where t = thickness of doubling plates in sixteenths, and C, T, and P are as above.

Note.—In the case of front plates of boilers in the steam space these numbers should be reduced 20 per cent., unless the plates are guarded from the direct action of the heat.

For steel tube plates in the nest of tubes the strength to be taken from

$$\frac{140 \times \text{T}^2}{\text{P}^2} = \text{working pressure in lbs. per sq. inch;}$$

where T = the thickness of the plates in sixteenths of an inch.

P = the mean pitch of stay tubes from centre to centre.

For wide water spaces between the nests of tubes, the strength to be taken from

$$\frac{\text{C} \times \text{T}^2}{\text{P}^2} = \text{working pressure in lbs. per sq. inch.}$$

where P = the horizontal distance from centre to centre of the bounding rows of tubes, and C = 120 where the stay tubes are pitched with two plain tubes between them, and are not fitted with nuts outside the plates.

C = 130 if they are fitted with nuts outside the plates.

C = 140 if each alternate tube is a stay-tube not fitted with nuts.

C = 150 if they are fitted with nuts outside the plates.

C = 160 if every tube in these rows is a stay-tube and not fitted with nuts.

C = 170 if every tube in these rows is a stay-tube, and each alternate stay-tube is fitted with nuts outside the plates.

The thickness of tube-plates of combustion-chambers in cases where the pressure on the top of the chambers is borne by these plates is not to be less than that given by the following rule:—

$$\text{T} = \frac{\text{P} \times \text{W} \times \text{D}}{1600 \times (\text{D} - d)}$$

where P = working pressure in lbs. per sq. inch.

W = width of combustion-chamber over plates in inches.

D = horizontal pitch of tubes in inches.

d = inside diameter of plain tubes in inches.

T = thickness of tube-plates in sixteenths of an inch.

The Strength of Girders supporting the Tops of Combustion-chambers and other Flat Surfaces.

$$\frac{C \times d^2 \times T}{(L - P) \times D \times L} = \text{working pressure in lbs. per sq. inch;}$$

where L = width between two plates, or tube-plate and back-plate of chamber.

P = pitch of stays in girders.

D = distance from centre to centre of girders.

d = depth of girder at centre.

T = thickness of girder at centre. All these dimensions to be taken in inches.

Wrought Iron.

$$C = \begin{cases} 6{,}000 \text{ if there is one stay to each girder.} \\ 9{,}000 \text{ if there are two or three stays to each girder.} \\ 10{,}000 \text{ if there are four or five stays to each girder.} \\ 10{,}500 \text{ if there are six or seven stays to each girder.} \\ 10{,}800 \text{ if there are eight stays or above to each girder.} \end{cases}$$

Wrought Steel.

$$C = \begin{cases} 6{,}600 \text{ if there is one stay to each girder.} \\ 9{,}900 \text{ if there are two or three stays to each girder.} \\ 11{,}000 \text{ if there are four or five stays to each girder.} \\ 11{,}550 \text{ if there are six or seven stays to each girder.} \\ 11{,}880 \text{ if there are eight stays or above to each girder.} \end{cases}$$

The Strength of Plain Furnaces to Resist Collapsing.

Where the length of the plain cylindrical part of the furnace exceeds 120 times the thickness of the plate,

$$\frac{1{,}075{,}200 \times T^2}{L \times D} = \text{working pressure in lbs. per sq. inch.}$$

Where the length of the plain cylindrical part of the furnace is less than 120 times the thickness of the plate,

$$\frac{50 \times (300\,T - L)}{D} = \text{working pressure in lbs. per sq. in.;}$$

where D = outside diameter of furnace in inches,

T = thickness of plates in inches,

L = length of plain cylindrical part in inches,

measured from the centres of the rivets connecting the furnaces to the flanges of the end and tube plates, or from the commencement of the curvature of the flanges of the furnace where it is flanged or fitted with Adamson rings.

In the furnaces referred to below the formulæ given are applicable if the steel used has a tensile strength of not less than 26 nor more than 30 tons per sq. inch. If the material of furnaces has a less tensile strength than 26 tons per sq. inch, then for each ton per sq. inch which the minimum tensile strength falls below 26, the coefficient is to be correspondingly decreased by $\frac{1}{26}$th part.

The strength of corrugated furnaces made of steel on Fox's, Morison's, or Deighton's plan to be calculated from

$$\frac{1{,}259 \times (T - 2)}{D} = \text{working pressure in lbs. per sq. inch.}$$

The Strength of Ribbed Furnaces (with ribs 9″ apart) to be calculated from the following formula:—

$$\frac{1{,}160 \times (T - 2)}{D} = \text{working pressure in lbs. per sq. inch.}$$

The strength of spirally corrugated furnaces to be calculated from the following formula:—

$$\frac{912 \times (T - 2)}{D} = \text{working pressure in lbs. per sq. inch;}$$

where T = thickness of plate in sixteenths of an inch, and

D = outside diameter of corrugated furnaces or smallest outside diameter of ribbed furnaces, in inches.

The strength of Holme's patent furnaces, in which the corrugations are not more than 16″ apart from centre to centre, and not less than 2″ high, to be calculated from the following formula:—

$$\frac{945 \times (T - 2)}{D} = \text{working pressure in lbs. per sq. inch.}$$

where T = thickness of plain portions of furnace in sixteenths of an inch.

D = outside diameter of plain parts of furnace in inches.

Rules for Determining Sizes of Shafts.

For compound engines with two cranks at right angles—

Diameter of intermediate shaft in inches

$$= (\cdot 04\text{A} + \cdot 006\text{D} + \cdot 02\text{S}) \times \sqrt[3]{\text{P}}.$$

For triple expansion engines with 3 cranks at equal angles—
Diameter of intermediate shaft in inches

$$= (\cdot 038\text{A} + \cdot 009\text{B} + \cdot 002\text{D} + \cdot 0165\text{S}) \times \sqrt[3]{\text{P}}.$$

For quadruple expansion engines with 2 cranks at right angles—

Diameter of intermediate shaft in inches

$$= (\cdot 034\text{A} + \cdot 011\text{B} + \cdot 004\text{C} + \cdot 0014\text{D} + \cdot 016\text{S}) \times \sqrt[3]{\text{P}}.$$

For quadruple expansion engines with 3 cranks—
Diameter of intermediate shaft in inches

$$= (\cdot 028\text{A} + \cdot 014\text{B} + \cdot 006\text{C} + \cdot 0017\text{D} + \cdot 015\text{S}) \times \sqrt[3]{\text{P}}.$$

For quadruple expansion engines with 4 cranks—
Diameter of intermediate shaft in inches

$$= (\cdot 033\text{A} + \cdot 01\text{B} + \cdot 004\text{C} + \cdot 0013\text{D} + \cdot 0155\text{S}) \times \sqrt[3]{\text{P}}.$$

where A = diameter of high pressure cylinder in inches.

B = diameter of first intermediate cylinder in inches.

C = diameter of second intermediate cylinder in inches.

D = diameter of low-pressure cylinder in inches.

S = stroke of pistons in inches.

P = boiler pressure above atmosphere in lbs. per sq. inch.

The diameter of crank shafts to be at least $\frac{21}{20}$ths of that of the intermediate shaft.

The diameter of the screw shaft is—

$\cdot 63\text{T} + \cdot 03\text{P}$, but is in no case to be less than $1 \cdot 07\text{T}$

where P is the diameter of the propeller, and

T the diameter of the intermediate shaft, both in inches.

TABLE OF THE WEIGHT AND STRENGTH OF CHAIN, AND HEMP AND WIRE ROPE.

Stud Chain			Rigging Chain			Iron Wire Rope			Steel Wire Rope for Standing Rigging			Hemp Rope (Hawser)			Hemp Rope (Shroud)			Hemp Rope (Cable)		
Dia.	Test Load	Wt. per Fath.	Dia.	Test Load	Wt. per Fath.	Circ.	Test Load	Wt. per Fath.	Circ.	Test Load	Wt. per Fath.	Circ.	Test Load	Wt. per Fath.	Circ.	Test Load	Wt. per Fath.	Circ.	Test Load	Wt. per Fath.
Ins.	Tons	Lbs.	Ins.	Tons	Lbs.	Ins.	Tons	Lbs.	Ins.	Tons	Lbs.	Ins.	Tons	Lbs.	Ins.	Tons	Lbs.	Ins.	Tons	Lbs.
5/8	7·0	23	1/8	·19	2·0	1/2	·30	·34	1/2	·45	·35	1	·25	·25	1	·20	·24	2	·64	·64
11/16	8·5	28	3/16	·41	3·0	3/4	·45	·55	3/4	·68	·56	1½	·55	·50	1½	·44	·49	2½	·99	·96
3/4	10·1	33	1/4	·75	4·75	1	·75	·98	1	1·13	1·01	2	1·00	1·00	2	·80	·97	3	1·44	1·28
7/8	13·8	45	5/16	1·12	6·75	1¼	1·00	1·50	1¼	1·50	1·55	2½	1·55	1·50	2½	1·24	1·46	3½	1·95	1·92
1	18·0	59	3/8	1·62	9·5	1½	1·55	2·06	1½	2·33	2·12	3	2·25	2·00	3	1·80	1·94	4	2·56	2·40
1⅛	22·8	71	7/16	2·25	13·25	1¾	2·30	3·00	1¾	3·45	3·09	3½	3·05	3·00	3½	2·44	2·91	4½	2·88	3·04
1¼	28·1	84	1/2	3·00	17	2	3·00	3·88	2	4·50	3·50	4	4·00	3·75	4	3·20	3·64	5	4·00	3·84
1⅜	34·0	101	9/16	3·75	21	2¼	4·00	4·75	2¼	6·00	4·89	4½	4·50	4·75	4½	4·40	4·61	5½	4·83	4·64
1½	40·5	121	5/8	4·62	25	2½	4·50	5·75	2½	6·75	5·89	5	6·25	6·00	5	5·00	5·82	6	5·76	5·44
1⅝	47·5	142	11/16	5·62	30	2¾	5·50	7·00	2¾	8·25	7·21	5½	7·55	7·25	5½	6·04	7·03	6½	6·76	6·40
1¾	55·1	165	3/4	6·75	36	3	7·10	8·50	3	10·65	8·75	6	9·00	8·50	6	7·20	8·20	7	7·84	7·36
1⅞	63·2	189	13/16	7·88	39	3¼	8·00	9·00	3¼	12·00	9·27	6½	10·55	10·00	6½	8·44	9·70	7½	8·83	8·48
2	72·0	215	7/8	9·12	48	3½	9·35	10·8	3½	14·02	11·12	7	12·25	11·50	7	9·80	11·16	8	10·24	9·60
2⅛	81·2	242	15/16	10·50	53	3¾	10·00	11·5	3¾	15·00	11·84	7½	13·80	13·25	7½	11·04	12·85	8½	11·55	10·88
2¼	91·1	272	1	12·00	61	4	11·8	13·3	4	17·70	13·69	8	16·00	15·00	8	12·80	14·56	9	12·96	12·16
2⅜	101·5	303	1⅛	15·25	73	4½	15·8	17·8	4½	23·70	18·33	8½	18·05	17·00	8½	14·44	16·50	9½	14·43	13·60
2½	112·5	336	1¼	18·75	92	5	18·6	21·5	5	27·90	22·14	9	20·25	19·00	9	16·20	18·50	10	16·00	15·04
2 9/16	118·2	350	1⅜	22·62	108	5½	22·5	26·5	5½	33·75	27·29	9½	22·55	21·25	9½	18·04	20·61	10½	16·60	16·48
2¾	129·3	407	—	—	—	6	27·2	31·5	6	40·80	32·44	10	25·00	23·50	10	20·00	22·79	11	19·36	18·24
3	145·8	484	—	—	—	6½	32·1	36·8	6½	48·15	37·91	10½	27·50	25·75	10½	22·00	24·97	11½	21·00	20·00
3¼	161·1	568	—	—	—	7	36·3	42·5	7	54·45	43·77	11	30·25	28·50	11	24·20	27·65	12	23·04	21·76
3½	176·4	659	—	—	—	7½	41·3	46·8	7½	61·95	48·20	12	36·00	34·00	12	28·80	32·90	13	27·04	25·44

TABLES OF SCANTLINGS

FRAMES, REVERSED FRAMES, FLOOR-

Numbers		Frames		Reversed frames	
For frames, reversed frames, and bulkheads	Spacing of frames	Dimensions of angles	Dimensions of angles before and abaft $\frac{1}{2}$ the length	Dimensions of reversed angles, all fore and aft	Dimensions of Z and channels bar frames for $\frac{1}{2}$ length amidships
	In.	In.	In.	In.	In.
31 and under 37	20	$2\frac{1}{2}\times2\frac{1}{2}\times\frac{5}{16}$	$2\frac{1}{2}\times2\frac{1}{2}\times\frac{4}{16}$	$2\frac{1}{2}\times2\frac{1}{2}\times\frac{4}{16}$	—
61 „ 65	23	$4\times3\times\frac{7}{16}$	$4\times3\times\frac{6}{16}$	$3\times3\times\frac{5}{16}$	$4\times3\times3\times\frac{6}{16}$
80 „ 85	24	$5\times3\frac{1}{2}\times\frac{8}{16}$	$5\times3\frac{1}{2}\times\frac{7}{16}$	$3\frac{1}{2}\times3\frac{1}{2}\times\frac{6}{16}$	$5\times3\frac{1}{2}\times3\frac{1}{2}\times\frac{8}{16}$
115 „ 122	26	$7\times3\frac{1}{2}\times\frac{12}{16}$	$6\frac{1}{2}\times3\frac{1}{2}\times\frac{9}{16}$	$4\frac{1}{2}\times4\times\frac{10}{16}$	$7\times3\frac{1}{2}\times3\frac{1}{2}\times\frac{12}{16}$

KEELS, STEMS, STERNPOSTS,

Numbers				Thickness of					
				Flat plate keels for all grades, breadth & thickness		Garboard strakes, length and thickness			
						100 A		90 A	
For keel, stem, sternpost, and plating	Bar keels for all grades	Stem of sailing-vessels and steamers and sternpost of sailing-vessels and paddle steamers	Stern frames of screw steamers	$\frac{1}{2}$ length amidships	Ends	Half length amidships	Ends	Half length amidships	Ends
	In.	In.	In.	In.		In.		In.	
2,600 and under 3,300	$6\times1\frac{1}{2}$	$5\frac{1}{2}\times1\frac{1}{2}$	$5\frac{1}{2}\times2\frac{1}{2}$	30 × 6	6	30 × 6	6	30 × 6	6
11,600 „ 12,400	$7\frac{1}{2}\times2\frac{1}{4}$	$7\times2\frac{1}{4}$	$7\times4\frac{1}{2}$	33 × 12	9	33 × 10	9	33 × 9	8
24,600 „ 26,500	$10\times2\frac{3}{4}$	$10\times2\frac{3}{4}$	10 × 6	36 × 16	12	36 × 12	11	—	—
64,600 „ 70,000	$12\times3\frac{1}{4}$	$12\times3\frac{1}{4}$	$13\times9\frac{1}{2}$	36 × 21	16	36 × 16	15	—	—

NOTE.—The numbers and spacing of the frames, reversed frames, and floor-plates, the thickness of bulkheads, are regulated by numbers, which are produced as follows :—

For one- and two-deck vessels the number is the sum of the measurements, in feet, of the half-moulded breadth of the vessel at the middle of the length, the depth from the upper part of the keel to the top of the upper-deck beams, with the normal round-up, and the girth of the half midship frame section of the vessel, measured from the centre line at the top of the keel to the upper-deck stringer plate. For 'three-deck' steam vessels, number is produced by the de-

BY LLOYD'S RULES.

PLATES, BULKHEADS, &c.

Dimensions of bulb angle-frames for ½ length amid-ships	Deep framing			Table for sizes of floors. Floor-plates in engine space of steam vessels to be $\frac{1}{20}$ of an inch thicker, and in the boiler space $\frac{2}{20}$ of an inch thicker than given in this table		
	Depth of framing	Width of stringers	Angles on stringers	Number for floors	For ½ length amidships	Thickness at ends
In.	In.	In.	In.		In.	In.
—	—	—	—	31 and under 32	$9 \times \frac{6}{20}$	$\frac{5}{20}$
$5 \times 3 \times \frac{9}{20}$	6	16	$4\frac{1}{2} \times 4 \times \frac{7}{20}$	60 " 62	$17\frac{1}{2} \times \frac{8}{20}$	$\frac{7}{20}$
$6 \times 3\frac{1}{2} \times \frac{11}{20}$	8	21	$6\frac{1}{2} \times 4 \times \frac{9}{20}$	80 " 84	$24\frac{1}{2} \times \frac{10}{20}$	$\frac{8}{20}$
$8\frac{1}{2} \times 3\frac{1}{2} \times \frac{12}{20}$	—	—	—	116 " 120	$36 \times \frac{10}{20}$	$\frac{8}{20}$

AND OUTSIDE PLATING.

outside plating in $\frac{1}{20}$ths of an inch

From garboard to the lower edge of sheerstrake				Sheerstrake for all grades, breadth and thickness		From main to upper sheerstrake in spar-deck'd vessels		Spar deck sheerstrake, breadth and thickness		Awning deck and bridge side-plating; also poops and forecastles
100 A		90 A								
Half length amidships	Ends	Half length amidships	Ends	Half length amidships	Ends	Half length amidships	Ends	Half length amidships	Ends	
				In.						
5 & 6	5	5	5	30 × 6	5	—	—	—	—	—
8 & 9	7 & 8	8	7	35 × 10	8	—	—	—	—	5
11 & 12	9	—	—	42 × 13	10	8	7	40 × 11	9	7
14 & 15	11 & 12	—	—	46 × 16	13	9	8	40 × 14	11	—

duction of 7 ft. from the sum of the measurements taken to the top of the upper-deck beams. For spar-decked vessels and awning-decked steam vessels, number is the sum of the measurements, in feet, taken to the top of the main deck beams, as described for vessels having one or two decks. The numbers of the keel, stem, stern-frame, keelson and stringer plates, the thickness of the outside plating and deck, also the numbers of the angle bars on beam stringer plates, and keelson and stringer angles in hold, are governed by the number obtained by multiplying that which regulates the size of the frames, &c., by the length of the vessel.

KEELSONS, KEELSON AND STRINGER

Numbers: To regulate keelsons, stringers, decks, rudders, and ceiling	Size of middle line keelsons standing upon floors, and thickness of rider-plate to keelson: Half length amidships	Thickness at ends	Thickness of intercostal keelson plates	Dimensions of angle bars for keelsons and stringers in hold for all grades	Dimensions of angle bar plates in spar-decked and awning-decked vessels
	In.	In.	In.	In.	In.
Under 2,800	$7\frac{1}{2}\times\frac{8}{20}$	$\frac{6}{20}$	$\frac{6}{20}$	$3\times3\times\frac{6}{20}$	$3\times2\frac{1}{2}\times\frac{6}{20}$
11,400 and under 12,800	$13\times\frac{13}{20}$	$\frac{9}{20}$	$\frac{7}{20}$	$4\frac{1}{2}\times3\frac{1}{2}\times\frac{7}{20}$	$3\frac{1}{2}\times3\frac{1}{2}\times\frac{7}{20}$
24,100 " 27,000	$20\times\frac{14}{20}$	$\frac{11}{20}$	$\frac{8}{20}$	$6\frac{1}{2}\times4\times\frac{8}{20}$	$4\times4\times\frac{7}{20}$
63,000 " 70,000	$32\times\frac{14}{20}$	$\frac{14}{20}$	$\frac{9}{20}$	$6\frac{1}{2}\times4\frac{1}{2}\times\frac{12}{20}$	$4\times4\times\frac{8}{20}$

* When the deck is of teak, it

Vessels of extreme proportions

The diameters of rudder heads for steam vessels to be calculated by the following

$$d=\frac{1}{21}\sqrt[3]{D\times b(2B-b)\times S^2}$$

When d = diameter of rudder head in inches, D = feet draught, B = greatest distances in inches, and S = speed in knots.

TABLE OF MINIMUM DIMENSIONS OF

Length of beam amidships	Upper deck beams amidships in steamers with one tier of beams only, and in all sail-vessels: 1 With one row of pillars	2 With two rows of pillars	3 With three rows of pillars	Upper and spar deck beams amidships in steamers with more than one tier of beams: 1 With one row of pillars	2 With two rows of pillars	3 With three rows of pillars	Main, middle, lower, and orlop deck beams amidships in steamers: 1 With one row of pillars	2 With two rows of pillars	3 With three rows of pillars
	Single angles	Single angles	Single angles	Bulb plate	Bulb plate	Bulb plate	Bulb plate	Bulb plate	Bulb plate
	In.	In.	In.	In.	In.	In.	In.	In.	In.
16	$4\frac{1}{2}\times3\times\frac{6}{20}$ B'lb plate	$4\frac{1}{2}\times3\times\frac{6}{20}$ B'lb plate	$4\times3\times\frac{6}{20}$	—	—	—	—	—	—
26	$6\frac{1}{2}\times\frac{6}{20}$	$6\times\frac{6}{20}$	$6\frac{1}{2}\times3\times\frac{7}{20}$ B'lb plate	$6\frac{1}{2}\times\frac{6}{20}$	$6\times\frac{6}{20}$	$5\times\frac{6}{20}$	$7\times\frac{7}{20}$	$6\frac{1}{2}\times\frac{6}{20}$	$5\frac{1}{2}\times\frac{6}{20}$
38	$9\frac{1}{2}\times\frac{8}{20}$	$9\times\frac{8}{20}$	$6\frac{1}{2}\times\frac{8}{20}$	$9\times\frac{8}{20}$	$8\times\frac{8}{20}$	$7\times\frac{8}{20}$	$10\times\frac{10}{20}$	$8\frac{1}{2}\times\frac{8}{20}$	$7\frac{1}{2}\times\frac{7}{20}$
50	—	—	$11\times\frac{11}{20}$	—	$10\frac{1}{2}\times\frac{10}{20}$	$9\times\frac{9}{20}$	—	$11\times\frac{11}{20}$	$10\times\frac{9}{20}$
62	—	—	—	—	—	$11\times\frac{11}{20}$	—	—	$12\times\frac{11}{20}$

ANGLES, DECKS, RUDDERS, AND CEILING.

Dimensions of angle bars on upper stringer plates	Rudder						Thickness of upper deck and diameter of bolt fastenings of wood deck			Thickness of wood ceiling in hold to upper part of bilges
	Sailing vessels			Steam vessels						
	Diameter at the head	Diameter of pintle	Section of main piece at heel	Diameter at the head	Diameter of pintle	Section of main piece at heel	Wood deck	Diameter of bolts	Steel deck	
In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
$3 \times 3 \times \frac{6}{20}$	$2\frac{7}{8}$	2	2×2	3	2	2×2	$2\frac{1}{2}$	$\frac{1}{2}$	—	2
$4 \times 4 \times \frac{7}{20}$	$4\frac{3}{4}$	$2\frac{3}{4}$	$3\frac{1}{4} \times 2\frac{3}{4}$	5	3	$3\frac{1}{4} \times 3$	$3\frac{1}{2}$	$\frac{9}{16}$	$\frac{6}{20}$	$2\frac{1}{4}$
$4\frac{1}{2} \times 4\frac{1}{2} \times \frac{10}{20}$	$7\frac{1}{2}$	$3\frac{3}{4}$	$6 \times 3\frac{3}{4}$	8	4	$6\frac{1}{4} \times 4$	4	$\frac{5}{8}$	$\frac{7}{20}$	$2\frac{1}{2}$
$5 \times 5 \times \frac{11}{20}$	—	—	—	11	$5\frac{1}{2}$	$8\frac{1}{2} \times 5\frac{1}{2}$	4	$\frac{5}{8}$	—	$2\frac{1}{2}$

may be one-sixth less in thickness.

to have additional strengthenings.

formula, but in no case is the diameter to be less than that given in the above table :—

inches from the centre of pintles to back of rudder, b = the greatest breadth of rudder in

BEAMS FITTED TO ALTERNATE FRAMES AMIDSHIPS.

Beams at awning and forecastle decks and bridge decks exceeding one-tenth the vessel's length			Beams at bridge decks less than one-tenth the vessel's length, and poop decks			Hold beams of extra strength	
1 With one row of pillars	2 With two rows of pillars	3 With three rows of pillars	1 With one row of pillars	2 With two rows of pillars	3 With three rows of pillars		
Single angles	Single angles	Single angles	Single angles	Single angles	Single angles	Plate or bulb plate	Angles
In.	In.	In.	In.	In.	In.	In.	In.
—	—	—	—	—	—	—	—
$6 \times 3 \times \frac{9}{20}$ bulb plate	$5\frac{1}{2} \times 3 \times \frac{8}{20}$ bulb plate	$5 \times 3 \times \frac{7}{20}$ bulb plate	$5 \times 3 \times \frac{7}{20}$ bulb plate	$4\frac{1}{2} \times 3 \times \frac{7}{20}$ bulb plate	$4 \times 3 \times \frac{7}{20}$	$7\frac{1}{2} \times \frac{7}{20}$	$3 \times 3 \times \frac{7}{20}$
$8 \times \frac{8}{20}$	$7 \times \frac{7}{20}$	$6 \times \frac{8}{20}$	$7 \times \frac{7}{20}$	$6\frac{1}{2} \times \frac{8}{20}$	$6 \times 3 \times \frac{9}{20}$ bulb plate	$10\frac{1}{2} \times \frac{10}{20}$	$4\frac{1}{2} \times 4 \times \frac{9}{20}$
—	$9\frac{1}{2} \times \frac{9}{20}$	$8\frac{1}{2} \times \frac{9}{20}$	—	$8\frac{1}{2} \times \frac{9}{20}$	$7\frac{1}{2} \times \frac{7}{20}$	$13 \times \frac{12}{20}$	$6 \times 4 \times \frac{9}{20}$
—	—	$10\frac{1}{2} \times \frac{12}{20}$	—	—	$10 \times \frac{9}{20}$	$14 \times \frac{13}{20}$	$6\frac{1}{2} \times 4\frac{1}{2} \times \frac{12}{20}$

STRINGER PLATES, STEEL

Plating numbers of vessels	Under 10 depths or under 8 breadths in length	10 to 11 depths or 8 to $8\frac{1}{2}$ breadths	11 to 12 depths or $8\frac{1}{2}$ to 9 breadths	12 to 13 depths or 9 to $9\frac{1}{2}$ breadths
	Dimensions of main			
2000–3000	$20 \times \frac{5}{20}$	$22 \times \frac{5}{20}$	$24 \times \frac{5}{20}$	$24 \times \frac{6}{20}$
17,000	$44 \times \frac{10}{20}$	$48 \times \frac{10}{20}$	$48 \times \frac{10}{20}$ steel dk. $\frac{6}{20}$ for half length amidship	$52 \times \frac{10}{20}$ compl. steel dk. $\frac{6}{20}$
36,000	complete steel up. dk. $\frac{7}{20}$ $57 \times \frac{10}{20}$ mid. dk. half length $\frac{7}{20}$	complete steel $57 \times \frac{10}{20}$ up. and mid. dk. $\frac{7}{20}$	complete steel $58 \times \frac{10}{20}$ up. and mid. dk. $\frac{7}{20}$	compl. steel up. $\frac{8}{20}$ $59 \times \frac{10}{20}$ dk. and mid. dk. $\frac{7}{20}$
72,000	complete steel $82 \times \frac{11}{20}$ up. and mid. dk. $\frac{9}{20}$	3 dks. $\frac{10}{20}$ $82 \times \frac{11}{20}$ $\frac{9}{20}$ and $\frac{7}{20}$	compl. steel up. dk. $\frac{10}{20}$ $82 \times \frac{11}{20}$ mid. dk. $\frac{9}{20}$ lr. dk. $\frac{7}{20}$	compl. steel up. dk. $\frac{10}{20}$ mid. dk. $\frac{9}{20}$ $82 \times \frac{11}{20}$ lr. dk. $\frac{7}{20}$ thick

DOUBLE BOTTOMS, CONSTRUCTED

Plating number for regulating scantlings	Centre girder—depth above top of keel, and thickness	Thickness of side girder	Number of side girders (exclusive of margin plates) on each side, with floors at alternate frames	Margin plate—depth (exclusive of flange) and thickness	Thickness of inner bottom plating: In engine and boiler space and middle line strake for half length amidships	Thickness of inner bottom plating: Middle line strake at ends	Thickness of inner bottom plating: Remainder of plating before and abaft the engine and boiler space
	In.	In.		In.	In.	In.	In.
Under 11,000 .	$32 \times \frac{8}{20}$	$\frac{6}{20}$	2	$20 \times \frac{6}{20}$	$\frac{7}{20}$	$\frac{6}{20}$	$\frac{6}{20}$
21,000 and under 24,000 . .	$38 \times \frac{10}{20}$	$\frac{7}{20}$	3	$28 \times \frac{8}{20}$	$\frac{9}{20}$	$\frac{8}{20}$	$\frac{7}{20}$
44,000 and under 51,000 . .	$48 \times \frac{11}{20}$	$\frac{9}{20}$ to $\frac{8}{20}$	4	$40 \times \frac{10}{20}$	$\frac{11}{20}$	$\frac{9}{20}$	$\frac{9}{20}$ to $\frac{8}{20}$

Decks, and Tie Plates.

13 to 14 depths or $9\frac{1}{2}$ to 10 breadths	14 to 15 depths or 10 to $10\frac{1}{2}$ breadths	15 to 16 depths or over $10\frac{1}{2}$ breadths	Ends of stringer plates	Hold and lower dk. beam stringer plates (extreme breadth); ends of ditto	Tie plate on beams fore and aft and diagonals; ends of ditto
stringer plates, &c.					
$27 \times \frac{6}{20}$	$30 \times \frac{6}{20}$	$33 \times \frac{6}{20}$	—	—	—
$54 \times \frac{10}{20}$ compl. steel dk. $\frac{8}{20}$	$58 \times \frac{10}{20}$ compl. steel dk. $\frac{7}{20}$	$62 \times \frac{10}{20}$	$29 \times \frac{8}{20}$	$32 \times \frac{9}{20}$ $25 \times \frac{8}{20}$	$13 \times \frac{10}{20}$ $13 \times \frac{8}{20}$
complete steel $59 \times \frac{10}{20}$ up. and mid. dk. $\frac{8}{20}$	compl. steel up. $60 \times \frac{10}{20}$ dk. $\frac{9}{20}$ and mid. dk. $\frac{8}{20}$	—	$45 \times \frac{9}{20}$	$50 \times \frac{9}{20}$ $38 \times \frac{8}{20}$	$20 \times \frac{10}{20}$ $20 \times \frac{8}{20}$
—	—	—	$62 \times \frac{9}{20}$	$65 \times \frac{10}{20}$ $53 \times \frac{8}{20}$	$33 \times \frac{10}{20}$ $33 \times \frac{8}{20}$

on the Cellular System.

Thickness of bracket or floor plates	Dimensions of angle bars			Connection of floors and outside brackets to margin plates	
	On centre girder	On margin plates	On side girders, intermediate and vertical angle bars	Diameter of rivets	Number of rivets in each flange
In.	In.	In.	In.	In.	
$\frac{6}{20}$	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{7}{20}$	$3 \times 3 \times \frac{7}{20}$	$3 \times 2\frac{1}{2} \times \frac{6}{20}$	$\frac{3}{4}$	5
$\frac{7}{20}$	$4 \times 4 \times \frac{8}{20}$	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{8}{20}$	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{7}{20}$	$\frac{3}{4}$	7
$\frac{8}{20}$ to $\frac{9}{20}$	$4 \times 4 \times \frac{10}{20}$	$4 \times 4 \times \frac{10}{20}$	$3\frac{1}{2} \times 3\frac{1}{2} \times \frac{10}{20}$	$\frac{7}{8}$	9

MARINE ENGINES.

Consumption of Coal per I.H.P.

The following figures may be taken as a good approximation of the consumption per I.H.P. per hour when the engines are being driven at a moderate speed:—

	Compound Engine.	Expansive Engine.
Above 2,000 I.H.P. . .	2 lbs.	3¼ lbs.
Between 1,000 and 2,000 I.H.P.	2¼ to 2½ lbs.	4 to 4½ lbs.
Under 1,000 I.H.P. . .	2½ „ 3 „	4½ „ 5 „

Note.—In either class of engine the consumption per I.H.P. per hour is about ½ lb. more when going at full speed.

Weight in Cwts. per I.H.P.

(*F. Proctor.*)

I.H.P.	Engines	Boilers	Screw Shafting	Spare Gear	Extra Work	Total
9,000 to 5,000	1·0 to 1·2	1·2 to 1·5	·25 to ·28	·125 to ·13	·18 to ·15	2·705 to 3·26
5,000 „ 1,000	1·2 „ 1·3	1·5 „ 1·9	·28 „ ·29	·13 „ ·20	·15 „ ·06	3·26 „ 3·75
1,000 „ 500	1·3	1·9 „ 2·8	·29	·20 „ ·29	·06 „ ·04	3·75 „ 4·75

Note.—The above weights are for expansive engines of good make; compound engines average from 10 to 20 per cent. heavier.

Consumption of Coal per Day, Hour, &c.

I.H.P. × ·06429 = tons per 24 hours at the rate of 6 lbs. per hour.
„ × ·05893 = „ „ „ 5½ „
„ × ·05357 = „ „ „ 5 „
„ × ·04821 = „ „ „ 4½ „
„ × ·04286 = „ „ „ 4 „
„ × ·03750 = „ „ „ 3½ „
„ × ·03214 = „ „ „ 3 „
„ × ·02679 = „ „ „ 2½ „
„ × ·02143 = „ „ „ 2 „
„ × ·01071 = „ „ „ 1 „

Stowage of Coal, &c.

The Admiralty allowance for coal = 48 cubic feet per ton of 2,700 lbs. = 40 cubic feet per ton of 2,240 lbs., which is the average generally allowed for coal-bunker space.

The bulk of wood is about 6 times as much as an equivalent of coal.

A cord of wood = 4 feet × 4 feet × 8 feet = 128 cubic feet.

A cubic foot of tallow weighs about 59 lbs.
„ „ waste „ „ 11 „
„ „ oil „ „ 56 „

PARTICULARS OF MODERN TRIPLE EXPANSION MACHINERY FOR BATTLESHIPS, CRUISERS, GUNBOATS, AND SLOOPS.

PARTICULARS	Battleship of 18,000 I.H.P.	Battleship of 13,500 I.H.P.	Battleship of 12,000 I.H.P.	1st Class Cruiser of 12,000 I.H.P.	2nd Class Cruiser of 9,000 I.H.P.	3rd Class Cruiser of 7,000 I.H.P.	Gunboat of 3,500 I.H.P.	Sloop of 1,400 I.H.P.
Twin screw or single	Twin	Twin	Twin	Twin	Twin	Twin	Twin	Single
No. and diameter of cylinders for each engine, H.P.	1—33½″	1—30″	1—40″	1—40″	1—33½″	1—20½″	1—22″	1—16½″
No. and diameter of cylinders for each engine, I.P.	1—54½″	1—49″	1—59″	1—59″	1—49″	1—33″	1—34″	1—26½″
No. and diameter of cylinders for each engine, L.P.	2—63″	1—80″	1—88″	1—88″	1—74″	1—54″	1—51″	1—42″
Length of stroke in inches	48″	51″	51″	51″	39″	27″	21″	24″
Steam pressure at engine . . lbs.	250	250	150	150	150	250	150	210
Revolutions per minute at full power	120	108	100	98 at 10,000 I.H.P.	140	220	250	200
Diameter of propeller	17′	16′-9″	17′	16′	13′	10′-6″	8′-3″	10′-6″
No. of blades in each propeller	4	4	14	3	3	3	3	2
Pitch " " "	18′-6″	20′	19′-9″	24′	17′-6″	11′	9′-6″	7′-6″
No. and diameter of air pumps to each engine	2—24″	1—30″	1—30″	1′-30″	26″	1—18½″	1—18½″	1—18″
Stroke of air pumps to each engine	18″	20″	20″	20″	16″	10″	8″	7″
Main condensers, no. to each engine	2	1	1	1	1	1	1	1
Main condensers, total cooling surface . . sq. ft.	19,000	14,500	13,500	13,500	10,000	8,000	4,000	1,650
Auxiliary condensers, no. in each engine-room	1	1	1	1	1	Nil	Nil	Nil
Auxiliary condensers, total cooling surface . . sq. ft.	2,900	2,200	1,800	1,600	1,000	Nil	Nil	Nil
Main centrifugal pump, no. and diameter in each engine room	2—45″	2—42″	2—48″	2—48″	1—40″	1—36″	1—26″	2—28″
Diameter of main circulating pipes to each condenser	15″ to each condenser	19″	18″	18″	14″	12½″	9″	8″

PARTICULARS OF MODERN TRIPLE EXPANSION MACHINERY FOR BATTLESHIPS, CRUISERS, GUNBOATS, AND SLOOPS—*continued.*

PARTICULARS	Battleship of 18,000 I.H.P.	Battleship of 13,500 I.H.P.	Battleship of 12,000 I.H.P.	1st Class Cruiser of 12,000 I.H.P.	2nd Class Cruiser of 9,000 I.H.P.	3rd Class Cruiser of 7,000 I.H.P.	Gunboat of 3,500 I.H.P.	Sloop of 1,400 I.H.P.
Diameter of crank shaft bearings . .	17½″	16½″	15¾″	15¾″	12¾″	10½″	7¾″	8″
Total length of crank shaft for one set of engines	13′	9′–6″	9′–6″	9′–6″	8′	8′	6′–3″	6′–6″
Diameter of crank pins . . .	19″	18″	16¼″	16¼″	13¼″	11½″	8″	8½″
Length " "	H.P. & I.P. 22″ L.P. 14″	20″	18″	18″	15″	15″	11″	12½″
Diameter of piston rod crosshead journals	H.P & I.P. 10½″ L.P. 8¼″	9¼″	10½″	10½″	8¾″	7½″	5½″	4½″
Length (total) of piston rod crosshead journals	H.P. & I.P. 21″ L.P. 16½″	18½″	14½″	14½″	11½″	14′	7¾″	10″
Piston rods, diameter H.P. and I.P. .	9″	8¼″	8¼″	8¼″	6¾″	5¾″	4½″	4¼″
" " L.P. . . .	7″	8¼″	8¼″	8¼″	6¾″	5¾″	4½″	4¼″
" guide surface H.P. and I.P. . . . . . each sq. ins.	870	740	700	700	500	340	170	216
Piston rods, guide surface L.P. sq. ins.	540	740	700	700	500	340	170	216
Diameter of slide-valve spindle . .	5½″	5½″	5½″	5½″	5″	3¼″	2¾″	2¾″
Thrust surface for each engine. sq. ins.	2,350	1,800	1,450	1,300	900	850	425	525
No. of cylinders for steam starting engine	2	2	2	2	2	2	2	2
Diameter of cylinders for steam starting engine	6″	6½′	7½″	7½″	5½″	3½″	4″	3½″
Stroke of cylinders for steam starting engine	8″	6″	7½″	7½″	7″	4″	4″	3½″
No. of cylinders for turning engine .	2	2	2	2	1	Nil	Nil	Nil
Diameter of cylinders for turning engine	5½″	4¾″	6″	6″	6″	Nil	Nil	Nil

PARTICULARS OF MODERN TRIPLE EXPANSION MACHINERY FOR BATTLESHIPS, CRUISERS, GUNBOATS, AND SLOOPS—*continued.*

PARTICULARS	Battleship of 18,000 I.H.P.	Battleship of 13,500 I.H.P.	Battleship of 12,000 I.H.P.	1st Class Cruiser of 12,000 I.H.P.	2nd Class Cruiser of 9,000 I.H.P.	3rd Class Cruiser of 7,000 I.H.P.	Gunboat of 3,500 I.H.P.	Sloop of 1,400 I.H.P.
Stroke of cylrs. for turning engine	6″	6″	6″	6″	6″	Nil	Nil	Nil
No. of main feed pumps	3 single cylinders	(*a*) 2 single cylrs. (*b*) 1 single cylr.	2 single cylinders	2 single cylrs.	2 single cylrs.	2 single cylrs.	2 double cylrs.	1 single cylr.
Single or double acting	double	double	double	double	double	double	double	double
Diameter of steam cylinders	17¾″	*a* 17½″–13¼′ *b*	15″	14″	13″	14½′	6¾″	10½″
„ main feed pumps	11½″	*a* 11½″–8¾″ *b*	11½″	10½″	10″	10	4½″	7″
Stroke of „ „ „	23″	*a* 21″–18″ *b*	24″	24″	20″	15½	6″	12″
Steam pressure at boilers . lbs.	300	300	155	155	155	300	155	260
Type of boilers	W.T. Belleville	W.T. Belleville	Cylindrical	Cylindrical	Cylindrical	W.T. Blechynden	Locomotive	W.T. Belleville
No. „	12–10 element. 12–9 element.	15—9 element 5—8 „	8 single-ended	8 single-ended	3 double ended 2 single-ended	8	4	4—7 element
Diameter of boilers or width	9 elem. 10′ wide 10 elem. 11′ wide	8 elem. 9′ wide 9 „ 10′ „	16′–3″ diameter	16′–1″ diameter	13′–2″ diameter	11′ wide	8′–6″ wide	8′–3″ wide
Length „	8′	8′	10′–1″	10′	18′–6″ D.E. 9′–6″ S.E.	11′ over all	15′–9″ over all	7′–9″
Total heating surface . sq. ft.	Gen. 28,360 Econ. 14,930	Gen. 21,770 Econ. 12,010	25,000	25,000	15,750	15,700	6,256	Gen. 2,820 Econ. 1,200
„ grate surface . sq. ft.	1,375	1,060	820	850	590	352	182	135
No. and diameter of funnels	2—11′–3″	1—9′–0″ 1—9′–0″ × 12′–6″	Oval 2—9′–3″ × 6′–6″	2—8′–3″	2—7′–0″	2—5′–3″	1—4′–0″	1—5′–3″

PARTICULARS OF MODERN TRIPLE EXPANSION MACHINERY FOR BATTLESHIPS, CRUISERS, GUNBOATS, AND SLOOPS—*continued.*

PARTICULARS	Battleship of 18,000 I.H.P.	Battleship of 13,500 I.H.P.	Battleship of 12,000 I.H.P.	1st Class Cruiser of 12,000 I.H.P.	2nd Class Cruiser of 9,000 I.H.P.	3rd Class Cruiser of 7,000 I.H.P.	Gunboat of 3,500 I.H.P.	Sloop of 1,400 I.H.P.
Height of funnels above grate	90'	90'	90'	90'	65'	55'	42'-6''	45'
No. of ventilating fans in stokehold	10	6	6 {Induced draught Fans in uptake}	8	6	8	4	3
Diameter of ventilating fans in stokehold	2—8'-3'' 8—6'-6''	4—8'-0'' 2—6'-0''	6'-6''	6'	5'	5'-6''	6'-6''	5'-6''
Air pressure in stokehold at full power	Nil	Nil	2·3'' vacuum in uptake at 12,000 I.H.P.	Nil (at 10,000 I.H.P.)	¾''	3''	2''	3/16''
Weight of machinery in engine room and screw ally	Tons 706	Tons 578	Tons 614	Tons 465	Tons 280	Tons 170	Tons 78	Tons 65
Weight of water in engine room and screw ally	18	15	14	12	6	6	2	1
Weight of machinery in boiler room	740	578	584	488	295	170	90	80
" water " "	48	83	168	150	113	18	30	4
" electric light machinery	20	24	29	16·25	7·5	9·5	2·1	3·25
" evaporating and distilling machinery	28 } 76 tons	19 } 89 tons	14 } 82 tons	7·45 } 45 tons	3·4 } 18 tons	6·5 } 20 tons	2·5 } 10 tons	2·75
Weight of steering engines	10	9	11	8·5	2·75	2	1·6	
"	17	14·5	14	10	4·35	3	3·8	
"		16	14	7·8				
"		12·5						
Weight (total) of machinery and water	1,664	1,386	1,367	1,190	714	388	210	156
Speed of ship at full power . knots	19	18½	17½	at 10,000 I.H.P.–18½	20¼	20¼	19½	18¼
Length of engine room	54'	44'	44'	40'	46'	38'	33'	26'
Total length of boiler rooms	94'	64'	80'	78'	72'	60'	56'	33'
Length of ship	405' b.p.	380' b.p.	390' b.p.	360'	300'	300'	250'	180'
Beam of ship	75'-6''	74'	75'	60'-8''	43'	36'-6'	27'-0''	32'-6''
Load draught of water, mean	26'-6''	26'	24'-9''	24'-9''	15'-9''	13'-6''	8'-9''	11'-6''

Description.	Carbon.	Hydrogen.	Oxygen.	Sulphur.	Ash, &c. including Nitrogen.	Total Heat of Evaporation.	Evaporative Power from and at 212°	One Ton occupies in Cubic Feet.
						Units.	Pounds.	
Welsh—Ebbw Vale . .	87·78	5·15	0·39	1·02	3·66	16221	16·79	—
„ Powell's Duffryn .	88·26	4·66	0·60	1·77	4·71	15788	16·34	—
„ Llangeunech .	84·97	4·26	3·50	0·42	6·85	14682	15·20	—
„ Græigola . .	84·87	3·84	7·19	0·45	1·91	14130	14·63	—
„ Average . .	83·87	4·79	4·15	1·43	5·89	14858	15·52	42·7
Newcastle Average . .	82·12	5·31	5·69	1·24	5·12	14820	15·32	45·3
Derbyshire Average .	79·68	4·94	10·28	1·01	4·06	13860	14·34	47·4
South Yorkshire . .	81·88	4·83	7·47	0·54	2·95	14296	14·71	46·0
Lancashire Average .	77·90	5·32	9·53	1·44	6·18	13918	14·56	45·2
Scotch „ . .	78·53	5·61	9·69	1·11	5·03	14164	14·65	42·0
Irish Anthracite . .	80·03	2·30	—	6·76	11·03	13302	14·5	35·7
American Anthracite .	88·54	—	—	0·04	8·60	—	—	42·35
„ Bituminous .	73·21	—	—	0·42	11·27	—	—	42·44
French Anthracite . .	86·17	2·67	2·85	—	8·56	14038	14·53	40·00
„ Hard Bituminous .	88·56	4·88	4·38	—	2·19	15525	16·10	42·75
„ Caking „ .	87·73	5·08	5·65	—	1·54	15422	16·00	42·75
Chilian Coal . .	63·56	5·43	14·84	2·50	14·13	11030	11·68	—
Indian „ Average .	70·20	—	—	—	22·9	—	—	—
Patent Fuel—Warlichs .	90·02	5·56	—	1·62	—	16495	17·07	—
„ „ Average .	83·40	4·97	2·79	1·26	6·01	15000	15·66	34·4
Lignite—Russian . .	73·72	6·09	20·19	ash neglected		14263	14·7	—
„ Poor kinds . .	66·51	4·72	28·77	„	„	11444	12·0	—
Coke—Best Durham .	85 to 92	—	—	0·25 to 2·0	4 to 12	12832	13·30	—
Woods—Beech . .	49·36	6·01	42·69	—	1·91			94·4
Oak . .	49·64	5·92	41·16	—	3·26	average		94·4
Birch . .	50·20	6·20	41·62	—	1·96	when dry		106·1
Fir . .	51·79	6·28	41·93	—	—	7800	8·1	—
Willow . .	49·96	5·96	39·56	—	4·33	—	—	124·7
Peat—Fairly dry . .	59·6	5·80	29·6	0·3	4·7	9951	10·30	—
Petroleum . .	84·7	13·1	2·2	—	—	0240	20·33	—

MEAN RESULTS OF THE TRIALS OF H.M.S.
VESSELS WITH CYLIN-

BY SIR JOHN DURSTON,

(From Transactions of the Institution

Name of Ship	Description of Trial	Proportion of Full Designed Power Developed	No. of Boilers in Use on the Trial	Grate Area in Use	Heating Surface in Use
				Sq. Ft.	Sq. Ft.
'Powerful' .	30 hours' coal consumption	·201	16	733	22,600
"	30 hours' coal consumption	·738	48	2,200	67,800
"	Unsuccessful full power	—	—	—	—
"	Full power First 4 hours .	1·08	48	2,200	67,800
"	Full power Second 4 hours	·909	48	2,200	67,800
'Terrible' .	30 hours' coal consumption	·203	16 to 20	733 to 916	22,600 to 28,250
"	30 hours' coal consumption	·74	48	2,200	67,800
"	Full power First 4 hours .	1·026	48	2,200	67,800
"	Full power Second 4 hours	·895	48	2,200	67,800
Recent representative battleship	30 hours' coal consumption	·518	8	820	25,045
"	8 hours' natural draught	·872	8	820	25,045
"	4 hours' full power .	1·023	8	820	25,045
Recent representative 2nd class cruiser	30 hours' coal consumption	·513	8	626	18,700
"	8 hours' natural draught	·855	8	626	18,700
"	4 hours' full power .	1·025	8	626	18,700

'POWERFUL' AND 'TERRIBLE' AND TWO
DRICAL BOILERS.

K.C.B., R.N.

of Naval Architects, 1897.)

Steam Pressure (by Gauge)		Fall of Pressure from H.P. Receiver to Steam Line of H.P. Diagrams		Jacket Pressures (by Gauge)			Receiver Pressures (by Gauge)		
Boilers	Engines	At Commencement of Stroke	At Middle of Steam Admission Line	H.P.	I.P.	L.P.	H.P.	I.P.	L.P.
Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
225	180	—	25	82	35	12·7	132	26	−(2·3)
232	196	8	35	127	42	11·6	194	51	10·2
—	—	—	—	—	—	—	—	—	—
257	207	4	34	177	53	12·2	205	69	15
237	197	2	32	167	47	12·9	192	64	13·8
208	162	13	28	82	34	9·5	140	32	1·8
223	199	33	53	134	46	10·6	192	53	12·8
229	197	18	42	159	50	11·7	195	70	22·5
225	196	22	52	150	46	11·4	190	62	18·0
139	136	18	40	138	40	10·1	136	37	3·6
150	148	5	20	133	17	7·7	148	56	11·1
152	147	6	23	146	49	13·1	147	59	13·6
145	142	3	21	not used	38	8·5	141	46	6·5
149	149	4	18	not used	56	13·1	146	55	10
151	147	7	14	not used	65	16·5	146	53	12

MEAN RESULTS OF THE TRIALS OF H.M.S. VESSELS WITH CYLINDRI-

BY SIR JOHN DURSTON,

(From Transactions of the Institution

Name of Ship	Mean Effective Pressures in the Cylinders: H.P.	I.P.	L.P. Forward	L.P. Aft	Mean Cut-off in the H.-P. Cylinder	Vacuum in Condensers	Revolutions of Main Engines per Minute	I.H.P. (total)
	Lbs.	Lbs.	Lbs.			Ins. of mercury		
'Powerful' .	36·85	11·53	5·89	5·47	0·42	26·9	67·26	5,044
"	85·65	27·56	14·15	14·04	5·95	26·6	102·84	18,459
"	—	—	—	—	—	—	112·39	24,796
"	95·27	40·48	17·54	17·6	0·74	26·0	114·46	25,900
"	89·76	36·22	16·09	16·11	0·69	26·1	109·62	22,725
'Terrible' .	30·68	14·11	6·37	6·66	0·278	26·8	64·42	5,073
"	74·17	28·92	15·49	15·39	0·602	26·2	102·7	18,500
"	86·73	35·81	21·07	21·79	0·738	25·9	112·0	25,648
"	80·21	32·17	18·4	19·13	0·69	26·0	108·89	22,370
Recent representative battleship	32·43	19·00	8·68		0·555	27·7	82·91	6,216
"	48·24	25·07	13·13		0·638	25·6	97·16	10,465
"	54·14	28·04	14·69		0·707	26·4	101·8	12,280
Recent representative 2nd class cruiser	38·35	18·55	8·9		0·39	26·6	117·85	4,925
"	54·0	28·55	12·3		0·63	28·1	136·15	8,208
"	66·55	30·45	13·5		0·75 to 0·69	27·9	144·95	9,840

(*a*) At 68·41 revolutions. (*b*) At 102·73 revolutions. (*c*) At 63·71 revolutions.
(*e*) At 112·26 revolutions. These revolutions were taken with the engines in

‘POWERFUL’ AND ‘TERRIBLE’ AND TWO
CAL BOILERS—*continued.*

K.C.B., R.N.

of Naval Architects, 1897.)

Mean Effective Pressure referred to the L.P. Cylinder	Absolute Pressure at Release in the L.P. Cylinder	Total Ratio of Expansion on Trial	Coal used per Hour		Propellers				Speed on Measured Mile or Deep-sea Course
			Per sq. ft. of Grate	Per I.H.P.	Diameter	Pitch	Slip per cent.	Expended Blade-area of each	
Lbs.	Lbs.		Lbs.	Lbs.	Ft. In.	Ft. In.		Sq Ft.	Knots
17·0	6·0	9·77	14·2	2·06	19 6	23 8½	10·3	78	14·347 (*a*)
40·8	12·6	7·74	15·4	1·835	”	”	12·8	78	20·957 (*b*)
—	—	—	—	—	”	”	16·2	78	22·035
51·4	17·7	6·62	not taken	—	”	”	18·5	78	21·8
47·1	15·7	6·96	not taken	—	”	”	—	78	not taken
17·9	6·3	10·86	18·1 to 14·5	2·6	”	24 0	11·0	92	13·434 (*c*)
40·9	15·0	7·0	14·4	1·71	”	”	14·4	92	20·964 (*d*)
52·1	18·9	6·09	not taken	—	”	”	15·7	92	22·41 (*e*)
46·7	17·0	6·39	not taken	—	”	”	—	92	not taken
23·8	8·0	—	13·8	1·82					
34·3	11·7	—	29·5	2·3					
38·4	14·0	—	not taken	—					
24·7	7·9	—	12·6	1·6					
35·6	11·2	—	28·8	2·2					
40·1	14·0	—	not taken	—					

There was a strong wind on the bow during this trial. (*d*) At 103·45 revolutions.
defective condition, and are lower than would now be obtained for the same power.

PARTICULARS OF MACHINERY

(From a Paper on 'Closed Stokeholds,' by R. SENNET, M.I.N.A.,

Particulars	'Inflexible'			'Colossus'	
Description of engines	3 cylinder vertical compound			3 cylinder vertical compound	
Diameters of cylinders in ins. — high pressure	2 of 70″			2 of 58″	
Diameters of cylinders in ins. — low pressure	4 of 90″			4 of 74″	
Length of stroke, ft. ins.	4′ 0″			3′ 8″	
Propeller — description	2 bladed			4 bladed	
Propeller — diameter, ft. ins.	20′ 2½″			17′ 8½″	
Propeller — pitch, ft. ins.	28′ 0½″			18′ 7¼″	
Boilers — number	12			10	
	FOUR EACH OF			EIGHT	TWO
Boilers — description	Oval 3 furnace	Oval 2 furnace	Oval dble.-ended 4 furnace	Oval 3 furnace	Oval 2 furnace
Boilers — transverse dimensions	13′ 7″ × 15′ 6″	11′ 1″ × 13′ 4″	9′ 4″ × 14′ 3″	12′ 9″ × 15′ 3″	7′ 10″ × 14′ 0″
Boilers — length, ft. ins.	9′ 0″	9′ 0″	17′ 0″	9′ 9″	9′ 9″
Load on safety valves, lbs.	60			64	
Furnaces — number	36			28	
	Twelve of	Eight of	Sixteen of	Twenty-four of	Four of
Furnaces — diameter	3′ 6″	3′ 3″	3′ 6″	3′ 5″	2′ 10″
Furnaces — length	6′ 0″	6′ 0″	6′ 6″	6′ 9″	6′ 9″
Furnaces — grate area in sq. ft.	829			645	
Heating surface of boilers in sq. ft. — tubes	18,654			14,747	
Heating surface of boilers in sq. ft. — total	22,288			17,507	
Area through tubes in sq. ft.	158			117	
Funnels — number	2			1	
Funnels — size	oval, 10′ 0″ × 8′ 0″			oval, 12′ 0″ × 8′ 0″	
Funnels — height above fire bars	70′ 3″			80′ 0″	
Ratios of *tube heating surface* / grate area	22·5			22·8	
Ratios of *area through tubes* / grate area	·190			·181	
Ratios of *area of funnels* / grate area	·160			·128	
Forced draught fans — number	—			—	
Forced draught fans — diameter, ft. ins.	—			—	
Duration of trial in hours	6			5	
Number of boilers used	12			10	
Mean steam pressure in boilers, lbs.	61·06			61·52	
Mean air pressure in boiler rooms, ins. of water	—			—	
Mean pressure in cylinders in lbs. per sq. in. — high pressure	29·55			40·66	
Mean pressure in cylinders in lbs. per sq. in. — low pressure	9·833			12·09	
Mean speed of piston in ft. per minute	586			585	
Mean revolutions per minute	73·26			89·96	
Indicated horse-power	8,463			7,492	
Area of fire-grate used in sq. ft.	829			645	
I.H.P. per sq. ft. of fire-grate	10·21			11·62	
Heating surface per I.H.P. in sq. ft. — tubes	2·20			1·97	
Heating surface per I.H.P. in sq. ft. — total	2·63			2·33	
Coal used per I.H.P. per hour, in lbs.	2·06			2·55	
Coal used per hour, in tons	7·80			8·53	
Remarks	Blast used last half-hour only			Blast used throughout the trial	
	Open stokeholds				

Note.—The indicated H.P. recorded, is that developed by the main
the feed and circulating pumps, blowing-

OF SOME OF H.M. SHIPS.
in the *Transactions of the Institution of Naval Architects.*)

'Phaeton'	'Mersey'	'Scout'	'Rodney'		'Howe'	'Trafalgar' (proposed)
Horizontal compound	Horizontal compound	Horizontal compound	3 cylinder vertical compound		3 cylinder vertical compound	Vertical triple expansion
2 of 42"	2 of 38"	2 of 26"	2 of 52"		2 of 52"	2 of 43"
						2 intermediate of 62"
2 of 78"	2 of 64"	2 of 46"	4 of 74"		4 of 74"	2 of 96"
4' 0"	3' 3"	2' 6"	3' 9"		3' 9"	4' 3"
4 bladed	3 bladed	3 bladed	4 bladed		4 bladed	Not yet decided
14' 0½"	13' 0"	10' 6"	15' 6"		15' 6"	
20' 1¾"	18' 5⅜"	12' 6"	19' 6"		19' 6"	
8	6	4	12		12	6
High cylindrical 3 furnace	Low cylindrical 3 furnace	Low cylindrical 3 furnace	Oval 3 furnace		Oval 3 furnace	High cylindrical 4 furnace
13' 5" dia.	10' 0" dia.	9' 3" dia.	11' 0" × 15' 0"		11' 0" × 15' 0"	16' 2" dia.
9' 3"	18' 9"	17' 10"	9' 8"		9' 8"	10' 8"
90	110	120	90		90	135
24	18	12	36		36	24
{18 of 3' 3" / 6 of 3' 0"}	3' 2"	2' 10"	3' 0"		3' 0"	3' 7½"
7' 0"	7' 0"	6' 0"	7' 0"		7' 0"	7' 4"
546	399	207	756		756	609
12,456	10,367	5,500	17,174		17,174	17,040
14,563	11,700	6,170	20,294		20,294	19,890
87·5	61	82	102		102	96
2	1	1	2		2	2
8' 0" dia.	7' 2" dia.	6' 6" × 4' 9"	9' 0" × 5' 6"		9' 0" × 5' 6"	7' 0" dia.
61' 8"	52' 6"	55' 0"	75' 0"		75' 0"	65' 0"
28·3	25·9	26·5	22·7		22·7	28
·160	·152	·154	·134		·134	·158
·138	·100	·125	·114		·114	·126
—	4	4	8		8	6
—	5' 0"	3' 6"	5' 0"		5' 0"	5' 6"
5	3	4	4	3	4	
8	6	4	12	9	12	
85·85	107·8	113·09	93·06	92·74	89·21	
—	2·02	1·52	1·4	1·39	2·05	
43·56	56·58	61·42	59·92	49·73	59·51	
11·43	22·82	24·81	12·8	12·1	18·43	
802	795	762	776	751	800	
100·26	122·34	152·33	108·42	100·18	106·63	
5,568	6·628	3,370	11,158	9,544	11,725	
546	399	207	756	567	756	
10·23	16·61	16·28	14·75	16·83	15·51	
2·23	1·56	1·63	1·54	1·35	1·46	
2·61	1·77	1·83	1·82	1·6	1·78	
2·39	2·43	2·6	2·2	—	2·16	
5·96	7·83	3·92	11	—	11·30	
Natural draught only / Open stokeholds	Forced draught					

engines only, and does not include the I.H.P. expended in working fans and other auxiliary machinery.

PARTICULARS OF

(Taken from *Transactions of the Institution*
Mr. WILLIAM JOHN, M.I.N.A., on

Name	Length	Breadth	Moulded Draft	Midship Area	Displacement	Indicated H.P.	Speed	Block Co-efficient	Midship Section Co-efficient	Prismatic Midship Section Co-efficient
	Ft. Ins.	Ft. Ins.	Ft. Ins.							
'City of Rome' .	542 6	52 0	21 5½	1,031	11,230	11,890	18·235	·649	·925	·702
'Normandie' . .	459 4	49 11	19 9¾	892	7,975	6,959	16·66	·614	·901	·681
'Furnessia' . .	445 0	44 6	22 2½	893	8,578	4,045	14*	·682	·903	·755
'Arizona' . . .	450 0	45 1½	18 9	758	6,415	6,300	17	·589	·895	·658
'Orient	445 0	46 0	21 4½	904	7,770	5,433	15·538	·621	·919	·676
'Stirling Castle' .	420 0	50 0	22 3	990	7,600	8,396	18·4	·569	·889	·639
'Elbe'	420 0	44 9	20 0	807	6,350	5,665	16·571	·591	·901	·655
'Pembroke Castle'	400 0	42 0	17 0	648	5,130	2435·8	13·25	·623	·9	·692
'Umbria' and 'Etruria' . .	500 0	57 0	22 6	1,090	9,860	14,321	20·18	·538	·896	·637
'Aurania' . . .	470 0	57 0	20 0	1,020	8,800	8,500	17·5*	·575	·942	·632
'America' . . .	432 0	51 0	26 7	1,272	9,550	7,354	17·8*	·57	·935	·608
'Oregon'	501 0	54 2	23 8	1,150	11,000	13,300	18·3	·599	·840	·67
'Servia'	515 0	52 0	23 3½	1,046	10,960	10,300	16·9*	·610	·862	·71
'Scotia, P.S.' . .	369 0	47 6	19 9	867	6,000	4,632	14·31*	·605	·92	·65
'Alaska'	500 0	50 0	21 0	949	9,210	"	"	·614	·904	·679
'Aller'	438 0	48 0	21 0	907	7,447	7,974	17·9	·590	·899	·656
'Ems'	430 0	46 10	20 7½	877	7,030	7,251	17·55	·593	·907	·652

* Mean speed of a voyage

Atlantic Steamers.

of Naval Architects, from an Article by
'Atlantic Liners.' Vol. xxviii.)

$\frac{D^{\frac{2}{3}} \times S^3}{\text{I.H.P.}}$	$\frac{D^{\frac{2}{3}} \times S^3}{\text{I.H.P.} \times \sqrt{\frac{\text{ent}}{10}}}$	Kirk's Method: Length of Entrance	Kirk's Method: Half Angle of Entrance	Kirk's Method: Wetted Surface	Coal Consumption: Per Day	Coal Consumption: Per I.H.P.	Cylinders: Diameter	Cylinders: Stroke	Boilers: Heating Surface	Boilers: Bar Surface	Working Pressure
							Ins.	Ins.			Lbs.
255	201·3	161·27	8° 29′	41,675	185	2·2	3 @ 46 3 @ 86	72	29,286	1,398	90
265	219·5	146·41	8° 44′	32,402	148	2	3 @ 35 $\frac{7}{16}$ 3 @ 74 $\frac{7}{8}$	67	21,404	756	85·2
284	273	108·7	10° 28′	33,436	97	2·2	49 & 100	66	10,396	440	90
269·2	217	153·79	7° 30′	28,938	”	”	1 @ 62 2 @ 90	66	”	”	90
270·8	225	144·17	8° 21′	31,867	”	”	1 @ 60 2 @ 85	60	”	”	75
286·8	233·7	151·3	8° 22′	31,131	”	”	1 @ 62 2 @ 90	66	21,161	787	100
275·5	229	144·6	7° 56′	28,038	”	”	1 @ 60 2 @ 85	60	”	”	”
284	258	122·9	8° 49′	22,347	44	1·7	43 & 86	57	7,896	288	90
260	191·8	184	6° 52′	37,454	315	2·1	1 @ 71 2 @ 105	72	38,817	1,606	110
266	204·6	170	8° 38′	34,252	215	2·2	1 @ 68 2 @ 91	72	23,284	1,001	,
345	265	169·3	8° 32′	35,702	185	”	1 @ 63 2 @ 91	66	”	882	”
227·9	190	164·3	9° 39′	40,264	310	2·2	1 @ 70 2 @ 104	72	38,047	1,428	110
231	192	145·3	10° 42′	40,626	205	2	1 @ 72 2 @ 100	78	27,483	1,014	”
208·9	186	126·8	13° 21′	25,357	168	3·4	2 @ 100	144	”	”	”
”	”	160·23	8° 2′	36,388	”	”	1 @ 68 2 @ 100	72	”	”	100
277	225	150·6	8° 10′	30,937	”	”	1 @ 44 1 @ 70 1 @ 100	72	22,630	799	150
273	223	149·4	8° 40′	29,764	”	”	1 @ 62 2 @ 86	60	19,700	780	100

across the Atlantic Ocean.

SHIP FITTINGS.

ADMIRALTY LENGTHS OF CHAIN CABLES.

A cable consists of eight lengths of $12\frac{1}{2}$ fathoms each, with a joining shackle to each length.

HAWSE PIPES AND DECK PIPES.

Hawse pipes should be 10 diameters, and deck pipes 8 diameters of the chain cable.

ADMIRALTY PROPORTIONS OF CHAINS, CABLES, &C.

Stud Link Chain.

Extreme length	= 6	times diameter of cable.
„ width	= 3·6	„ „
Diameter of stay pin at middle	= ·6	„ „
„ „ ends	= diameter of cable.	

Open Link Chain.

Extreme length	= 6	times diameter of chain.
„ width	= 3·6	„ „

Rigging Chain.

Extreme length	= 5	times diameter of chain.
„ width	= $3\frac{1}{2}$	„ „

Cat Chain.

Extreme length	= $4\frac{3}{4}$	times diameter of chain.
„ width	= $3\frac{1}{2}$	„ „

Ordinary Long Shackles.

Extreme length	= 6	times diameter of chain.
„ width	= 4	„ „

Diameter of pin in shackles up to $1\frac{1}{2}''$ diameter $= \frac{1}{8}''$ more than diameter of shackle.

Diameter of pin in shackles above $1\frac{1}{2}''$ diameter $= \frac{1}{4}''$ more than diameter of shackle.

For diameter of iron of shackle see page 475.

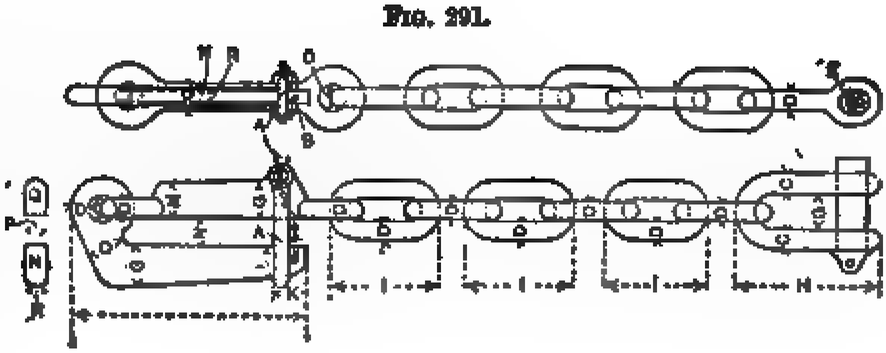
Extreme diameter of shackle eyes = 1·4 times the diameter of chain plus the diameter of pin.

Blake's Stoppers.

Fig. 290.

A	·5
B	·63
C	·875
D	·75
E	1·0
F	1·25
G	1·5
H	6·0
I	4·2
J	9·65
K	1·25
L	1·21
M	1·4
N	1 1
O	1·6
P	·69
Q	1·2
R	·75

Fig. 291.



Sizes of Blake's Stopper. (Fig. 290.)

Sizes of Cable	A	B	C	D	E	F	G	H	I	J	K	L	M	N
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	1 7/16	1 3/8	1 1/4	13/16	7 1/2	2 7/16	2	5/8	1/4	2 13/16	6	3 1/2	9/16	2 1/4
1 1/8	1 5/8	1 1/2	1 3/8	15/16	8 7/16	2 11/16	2 1/4	11/16	5/16	3 5/16	6 3/4	3 15/16	5/8	2 9/16
1 1/4	1 13/16	1 11/16	1 1/2	1	9 3/8	3	2 1/2	3/4	5/16	3 11/16	7 1/2	4 3/8	11/16	2 13/16
1 3/8	2	1 7/8	1 5/8	1 1/8	10 5/16	3 5/16	2 3/4	13/16	3/8	4 1/16	8 1/4	4 13/16	3/4	3 1/8
1 1/2	2 3/16	2	1 13/16	1 3/16	11 1/4	3 5/8	3	15/16	3/8	4 3/8	9	5 1/4	13/16	3 3/8
1 5/8	2 3/8	2 3/16	1 15/16	1 5/16	12 3/16	3 15/16	3 1/4	1	7/16	4 3/4	9 3/4	5 11/16	7/8	3 11/16
1 3/4	2 9/16	2 3/8	2 1/8	1 7/16	13 1/8	4 3/16	3 1/2	1 1/16	7/16	5 1/8	10 1/2	6 1/8	15/16	3 15/16
1 7/8	2 11/16	2 1/2	2 1/4	1 1/2	14 1/16	4 1/2	3 3/4	1 1/8	1/2	5 1/2	11 1/4	6 9/16	1	4 1/4
2	2 7/8	2 11/16	2 3/8	1 5/8	15	4 13/16	4	1 3/16	1/2	5 7/8	12	7	1 1/8	4 1/2
2 1/8	3 1/16	2 13/16	2 9/16	1 11/16	15 15/16	5 1/8	4 1/4	1 1/4	9/16	6 1/4	12 3/4	7 7/16	1 3/16	4 13/16
2 1/4	3 1/4	3	2 11/16	1 13/16	16 7/8	5 7/16	4 1/2	1 3/8	9/16	6 5/8	13 1/2	7 7/8	1 1/4	5 1/16
2 3/8	3 7/16	3 3/16	2 13/16	1 15/16	17 13/16	5 11/16	4 3/4	1 7/16	5/8	6 15/16	14 1/4	8 5/16	1 5/16	5 3/8
2 1/2	3 5/8	3 5/16	3	2	18 3/4	6	5	1 1/2	5/8	7 5/16	15	8 3/4	1 3/8	5 5/8
2 9/16	3 11/16	3 7/16	3 1/16	2 1/16	19 3/16	6 1/8	5 1/8	1 9/16	5/8	7 1/2	15 3/8	9	1 7/16	5 3/4

Sizes of Blake's Stoppers. (Fig. 291.)

Sizes of Cable	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
1	1/2	5/16	7/8	3/4	1	1 1/4	1 1/2	6	4 3/16	9 9/16	1 3/8	1 1/4	1 7/16	1 1/8	1 5/8	11/16	1 1/4	3/4
1 1/8	9/16	3/8	1	7/8	1 1/8	1 7/16	1 11/16	6 3/4	4 3/4	10 3/4	1 1/2	1 3/8	1 9/16	1 1/4	1 13/16	3/4	1 3/8	7/8
1 1/4	5/8	7/16	1 1/8	15/16	1 1/4	1 9/16	1 7/8	7 1/2	5 1/4	11 15/16	1 11/16	1 1/2	1 3/4	1 3/8	2	7/8	1 1/2	15/16
1 3/8	11/16	7/16	1 3/16	1 1/16	1 3/8	1 11/16	2 1/16	8 1/4	5 3/4	13 1/8	1 7/8	1 11/16	1 15/16	1 1/2	2 3/16	15/16	1 5/8	1 1/16
1 1/2	3/4	1/2	1 5/16	1 1/8	1 1/2	1 7/8	2 1/4	9	6 5/16	14 5/16	2	1 13/16	2 1/8	1 11/16	2 7/16	1 1/16	1 13/16	1 1/8
1 5/8	13/16	1/2	1 7/16	1 1/4	1 5/8	2 1/16	2 7/16	9 3/4	6 13/16	15 1/2	2 3/16	1 15/16	2 5/16	1 13/16	2 5/8	1 1/8	1 15/16	1 1/4
1 3/4	7/8	9/16	1 9/16	1 5/16	1 3/4	2 3/16	2 5/8	10 1/2	7 3/8	16 11/16	2 3/8	2 1/8	2 7/16	1 15/16	2 13/16	1 3/16	2 1/8	1 5/16
1 7/8	15/16	5/8	1 5/8	1 7/16	1 7/8	2 3/8	2 13/16	11 1/4	7 7/8	17 7/8	2 1/2	2 1/4	2 5/8	2 1/16	3	1 5/16	2 1/4	1 7/16
2	1	5/8	1 3/4	1 1/2	2	2 1/2	3	12	8 7/16	19 1/8	2 11/16	2 7/16	2 13/16	2 3/16	3 3/16	1 3/8	2 3/8	1 1/2
2 1/8	1 1/16	11/16	1 7/8	1 5/8	2 1/8	2 11/16	3 3/16	12 3/4	8 15/16	20 5/16	2 7/8	2 9/16	3	2 5/16	3 7/16	1 7/16	2 9/16	1 5/8
2 1/4	1 1/8	3/4	2	1 11/16	2 1/4	2 13/16	3 3/8	13 1/2	9 7/16	21 1/2	3 1/16	2 3/4	3 3/16	2 1/2	3 5/8	1 9/16	2 11/16	1 11/16
2 3/8	1 3/16	3/4	2 1/16	1 13/16	2 3/8	3	3 9/16	14 1/4	10	22 11/16	3 3/16	2 7/8	3 5/16	2 5/8	3 13/16	1 5/8	2 13/16	1 13/16
2 1/2	1 1/4	13/16	2 3/16	1 7/8	2 1/2	3 1/8	3 3/4	15	10 1/2	23 7/8	3 3/8	3	3 1/2	2 3/4	4	1 3/4	3	1 13/16
2 9/16	1 5/16	13/16	2 1/4	1 15/16	2 9/16	3 5/16	3 7/8	15 3/8	10 3/4	24 1/2	3 7/16	3 1/8	3 9/16	2 13/16	4 1/8	1 3/4	3 1/16	1 15/16

SLIPS FOR CHAIN RIGGING, &c.

FIG. 292.

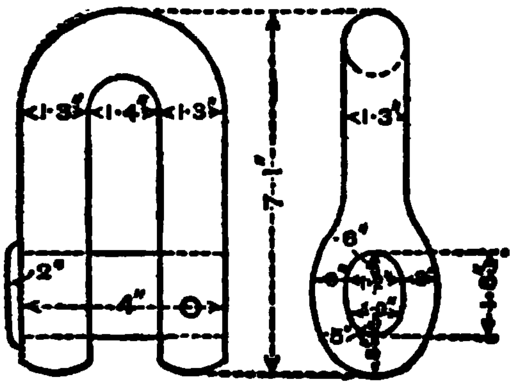


FIG. 293.

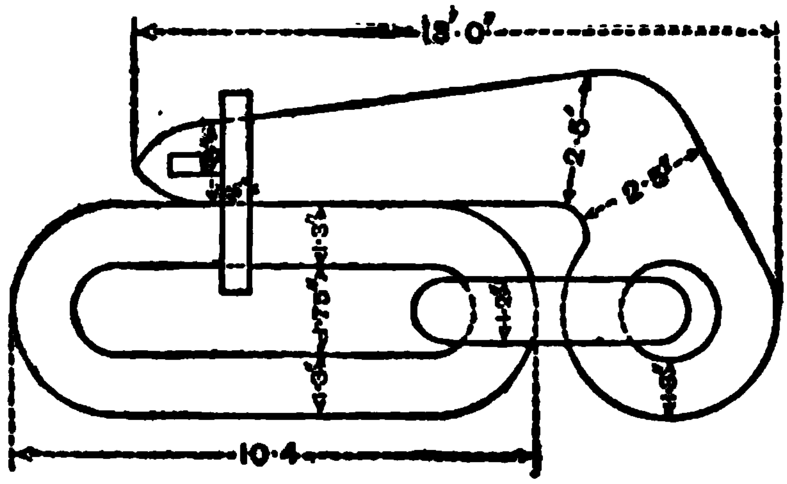
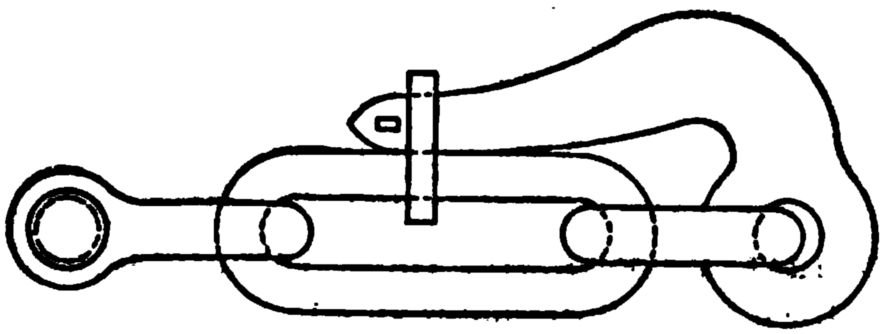


FIG. 294.



SIZES OF IRON IN INCHES FOR STRAIGHT AND MONKEY-TAILED SLIPS. (Figs. 292, 293, and 294.)

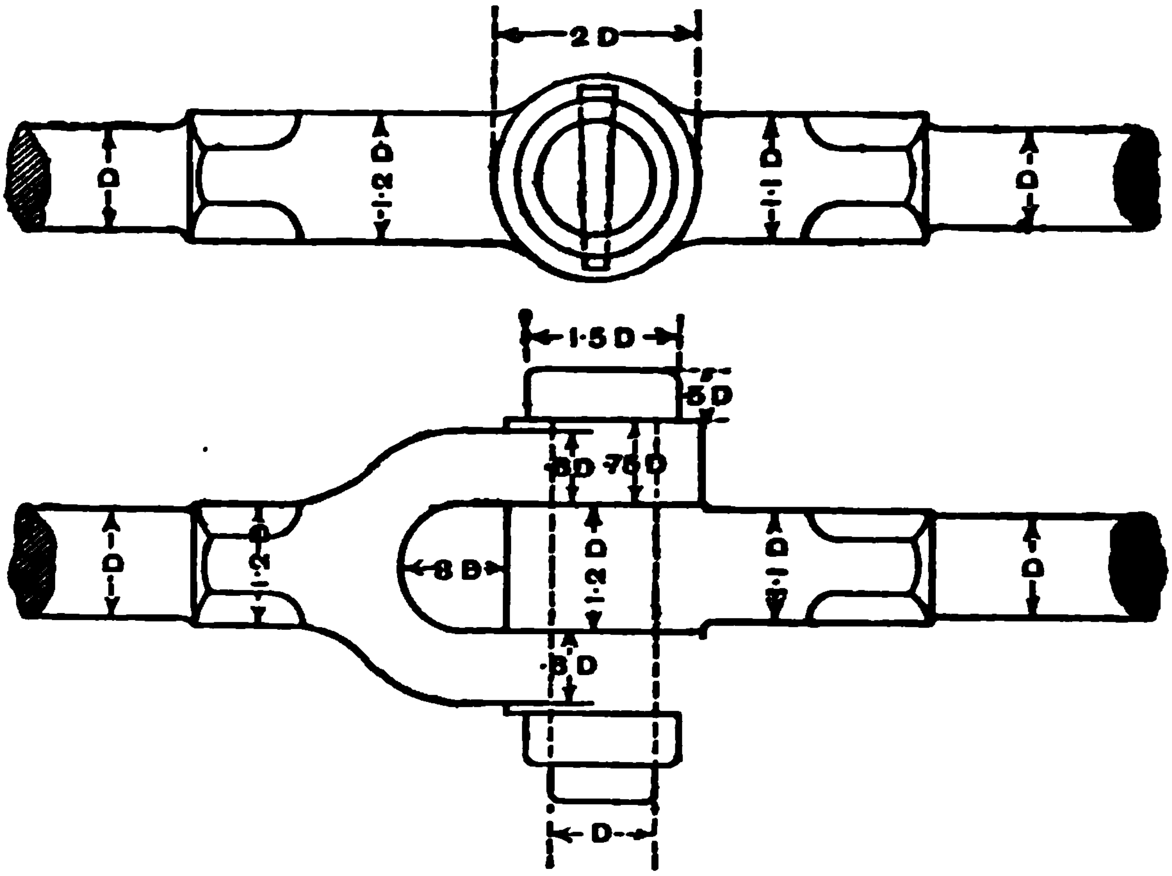
Size of Chain	Straight Slip	Monkey Slip	Short Link	Long Link	Buckler	Shackle	Size of Chain	Straight Slip	Monkey Slip	Short Link	Long Link	Buckler	Shackle
$\frac{3}{8}$	$\frac{7}{8}$	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{5}{8}$	$\frac{7}{8}$	$1\frac{5}{8}$	$1\frac{3}{4}$	1	$1\frac{1}{8}$	$\frac{5}{8}$	$1\frac{1}{8}$
$\left.\begin{matrix}\frac{7}{16}\\\frac{1}{2}\end{matrix}\right\}$	1	$1\frac{1}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{3}{4}$	1	$1\frac{7}{8}$	2	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$	$1\frac{1}{4}$
$\left.\begin{matrix}\frac{9}{16}\\\frac{5}{8}\end{matrix}\right\}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{8}$	$\left\{\begin{matrix}\frac{3}{4}\\\frac{7}{8}\end{matrix}\right.$	$1\frac{1}{8}$	2	$2\frac{1}{4}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$\frac{7}{8}$	$1\frac{3}{8}$
$\left.\begin{matrix}\frac{11}{16}\\\frac{3}{4}\end{matrix}\right\}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{1}{2}$	1	$1\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{3}{8}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$\frac{7}{8}$	$1\frac{1}{2}$

Note.—The pins of the shackles are $\frac{1}{8}''$ larger than iron of shackle.

Knuckle Joint.

Diameter to be taken as unit.

Fig. 295.



Admiralty Tests for Iron Armour Bolts.

The test for a bolt 2″ diameter should be the fall of 15 cwt. through 30 feet, or 20 cwt. through $22\frac{1}{2}$ feet.

In preparing the bolt for testing, the screw thread should project beyond the bolt, the 2″ of iron being left after the thread is cut (fig. 296).

Admiralty Tests for India-rubber Washers.

To be vulcanised india-rubber sheet made of 45 per cent. of best Para caoutchouc and the remainder of white oxide of zinc and sulphur, the sulphur not to exceed 3 per cent., to endure a dry heat of 270 degrees Fahrenheit for one hour.

Diameters of Bolts for Armour Plates.

Thickness of Plate	Diameter of Bolt	Thickness of Plate	Diameter of Bolt
From 2″ to 3″	$1\frac{1}{2}$″	Above 8″ to 9″	3″
Above 3″ to 4″	$1\frac{3}{4}$″	„ 9″ to 10″	$3\frac{1}{4}$″
„ 4″ to 5″	2″	„ 10″ to $10\frac{1}{2}$″	$3\frac{1}{2}$″
„ 5″ to 6″	$2\frac{1}{4}$″	„ 11″ to 12″	$3\frac{3}{4}$″
„ 6″ to 7″	$2\frac{1}{2}$″	Above 12″ to 13″	4″
„ 7″ to 8″	$2\frac{3}{4}$″	„ 13″ to 14″	$4\frac{1}{2}$″

DIMENSIONS IN INCHES OF BOLTS, &c., FOR ARMOUR PLATES.
(*See Sketches*, fig. 296.)

Diameter of Bolt, A	Length of Head, B	Diameter of Head, C	Mooting of Points, D	No. of Threads per Inch, E	Thickness of Nut, F	Inside Diameter of Nut, G	Metal round Bolt in Nut, H	Thickness of Iron for Making Cups, J	Thickness of Cup at Base, finished, K	Do. at Sides: Top, L	Do. at Sides: Bottom, M	Thickness of Plate Washer, N	Thickness of India-rubber Washer, O
4 1/2	5 1/16	6 5/16	1/8 of an inch for all diameters	3	Equal to diameter of Bolt in all cases	4 1/32	1 5/8	9/16	1/2	3/8	9/16	1/2	1
4 1/4	4 3/4	6		3 1/4		3 13/16	1 9/16	9/16	1/2	3/8	9/16	1/2	1
4	4 1/2	5 5/8		3 1/2		3 9/16	1 1/2	9/16	1/2	3/8	9/16	1/2	1
3 3/4	4 1/4	5 1/4		4		3 11/32	1 7/16	9/16	1/2	3/8	9/16	1/2	1
3 1/2	3 15/16	4 7/8		4		3 3/32	1 3/8	9/16	1/2	3/8	9/16	1/2	1
3 1/4	3 5/8	4 9/16		5		2 7/8	1 9/32	7/16	3/8	1/4	7/16	3/8	7/8
3	3 3/8	4 1/4		5		2 5/8	1 7/32	7/16	3/8	1/4	7/16	3/8	7/8
2 3/4	3 1/8	3 7/8		5 1/2		2 13/32	1 1/8	7/16	3/8	1/4	7/16	3/8	7/8
2 1/2	2 13/16	3 1/2		6		2 5/32	1 1/16	7/16	3/8	1/4	7/16	3/8	7/8
2 1/4	2 1/2	3 1/8		6		1 15/16	31/32	5/16	1/4	3/16	5/16	1/4	3/4
2	2 1/4	2 7/8		7		1 23/32	7/8	5/16	1/4	3/16	5/16	1/4	3/4
1 3/4	2	2 5/8		7		1 15/32	25/32	5/16	1/4	3/16	5/16	1/4	3/4
1 1/2	1 11/16	2 3/8		8		1 1/4	3/4	5/16	1/4	3/16	5/16	1/4	3/4

Note.—The shank should be reduced to a diameter slightly below that at the deepest cut of the thread.

DIMENSIONS IN INCHES OF WOOD BELAYING CLEATS.
(*See Sketch*, fig. 297.)

1	2	3	4	5	6	7	8	9
8	1	7/8	2 1/2	1 3/8	2 3/4	2 1/8	3/8	1
10	1 3/8	1 1/8	3 1/4	1 7/8	4	3 3/8	1/2	1 5/8
12	1 5/8	1 1/4	4	2 1/8	4 1/4	3 5/8	5/8	1 3/4
14	1 7/8	1 3/8	4 1/2	2 1/4	5	4	7/8	1 7/8
16	2 1/8	1 1/2	5 1/2	2 5/8	5 3/4	4 1/2	1	2
18	2 3/8	1 5/8	6	3	6 1/4	5	1 1/8	2 1/4
20	2 5/8	1 3/4	7	3 1/4	6 3/4	5 5/8	1 1/4	2 1/2
22	2 3/4	2	7 1/2	3 5/8	7 1/2	6 1/4	1 3/8	2 7/8
24	3 1/8	2 1/8	8	4	8	6 3/8	1 1/2	3 1/8
26	3 3/8	2 1/4	8 1/2	4 1/4	9	6 5/8	1 5/8	3 1/4
28	3 5/8	2 3/8	9 1/4	4 5/8	9 5/8	7	1 5/8	3 3/8
30	4	2 3/4	10	5	10 1/2	7 3/8	1 5/8	3 1/2
32	4 1/2	3	10 1/2	5 3/8	10 5/8	7 3/4	1 3/4	3 5/8

FIG. 296.—ARMOUR BOLT.

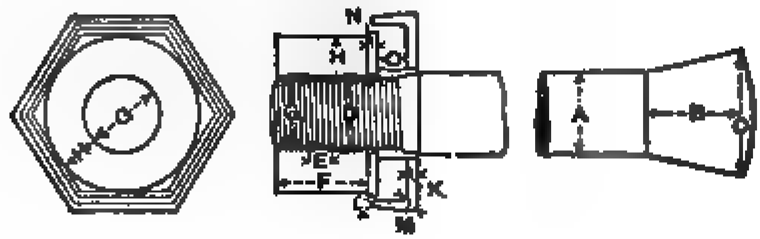
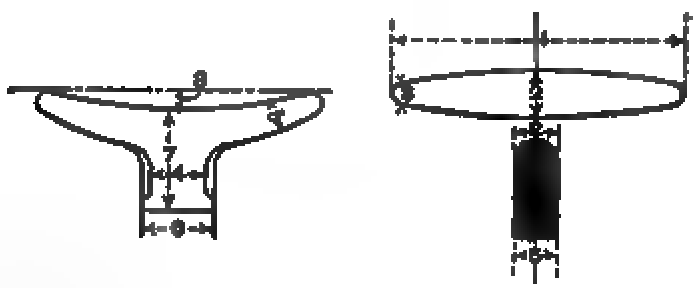


FIG. 297.—WOOD BELAYING CLEAT.



NUTS AND SCREWS TO DECK BOLTS.

Nuts	Width of nut over side .	1½	The diameter of bolt
	Thickness	1	
Heads	Width or diam. over head	= Width over angle of nut	
	Thickness of head . .	= ⅞	The diameter of bolt
	Length of square below head	= 1	

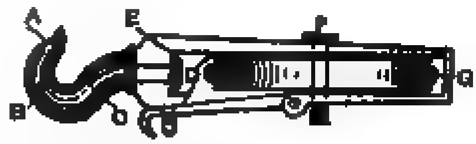
DIMENSIONS IN INCHES OF SNATCH BLOCK BINDINGS.

(*See Sketch*, fig. 298.)

Size of Block	A	B	C	D	E	F	G	Length of Hook	Size of Pin
8	[illegible]	1¼ [illegible]	1¼	2¼ [illegible]	1½ [illegible]	2 × [illegible]	1	8	[illegible]
9	[illegible]	1½ [illegible]	1$\frac{5}{16}$	2⅜ [illegible]	1½ [illegible]	2⅛ × [illegible]	1 [illegible]	9	[illegible]
10	[illegible]	1⅝ [illegible]	1⅜	2½ [illegible]	1⅝ [illegible]	2¼ × [illegible]	1 [illegible]	10	[illegible]
11	[illegible]	1¾ [illegible]	1⅜	2¾ [illegible]	1¾ [illegible]	2⅜ × [illegible]	1	11	[illegible]
12	[illegible]	1¾ [illegible]	1½	3 [illegible]	1⅞ [illegible]	3⅛ × [illegible]	1	11½	1
13	1	1⅞ [illegible]	1⅝	3¼ [illegible]	2 [illegible]	3¼ × [illegible]	1	12½	1$\frac{1}{16}$
14	1	1⅞ [illegible]	1$\frac{11}{16}$	3⅜ [illegible]	2⅛ [illegible]	3⅜ × [illegible]	1 [illegible]	13	1⅛
15	1⅛	1⅞ [illegible]	1¾	3½ [illegible]	2¼ [illegible]	3⅝ × [illegible]	1 [illegible]	14	1$\frac{3}{16}$
16	1⅛	1⅞ [illegible]	1⅞	3⅝ [illegible]	2⅜ [illegible]	4⅛ × [illegible]	1	15	1¼
17	1¼	2 [illegible]	1$\frac{15}{16}$	3¾ [illegible]	2½ [illegible]	4¼ × [illegible]	1	15½	1¼
18	1¼	2⅛ [illegible]	2	4 [illegible]	2⅝ [illegible]	4⅜ × [illegible]	2	16	1$\frac{5}{16}$
19	1¼	2¼ [illegible]	2⅛	4⅛	2$\frac{11}{16}$ [illegible]	4½ × [illegible]	2	17	1⅜
20	1⅜	2⅜ [illegible]	2¼	4¼	2¾ [illegible]	5⅛ × [illegible]	2	18	1⅜
21	1⅜	2½ [illegible]	2⅜	4⅜ [illegible]	2⅞ [illegible]	5¼ × 1	2 [illegible]	19	1$\frac{7}{16}$
22	1½	2⅝ [illegible]	2½	4 [illegible]	3 [illegible]	5⅜ × 1$\frac{1}{16}$	2 [illegible]	20	1½
23	1½	2¾ [illegible]	2⅝	5¼ × 2¼	3⅛ [illegible]	5½ × 1⅛	2	21	[illegible]
24	1⅝	2⅞ [illegible]	2¾	5½ × 2⅜	3¼	5⅝ × 1$\frac{3}{16}$	2	22	1⅝
25	1⅝	2$\frac{15}{16}$ [illegible]	2⅞	5¾ × 2½	3$\frac{5}{16}$ [illegible]	5¾ × 1¼	2	23	[illegible]
26	1¾	3$\frac{1}{16}$ [illegible]	3	6 × 2⅝	3⅜ [illegible]	5⅞ × 1¼	2	24	[illegible]

Sizes of Iron Blocks.								
Diameter of Sheave	Width of Groove	Size of Chain	Diameter of Sheave	Width of Groove	Size of Chain	Diameter of Sheave	Width of Groove	Size of Chain
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
2½	[illegible]	—	7	1¼	⅜	13	—	—
3¼	[illegible]	—	8	1⅜	$\frac{7}{16}$	14	2¾	¾
4	[illegible]	—	9	1½	½	15	3	[illegible]
4½	[illegible]	$\frac{3}{16}$	10	2	$\frac{9}{16}$	16	3¼	⅞
5	[illegible]	¼	11	2¼	⅝	—	—	—
6	1	$\frac{5}{16}$	12	2½	$\frac{11}{16}$	—	—	—

FIG. 298.



RIGGING SLIPS AND SCREWS.

FITTINGS FOR LOWER PART OF SCREWS TO PREVENT THEM WORKING LOOSE.

FIG. 299.

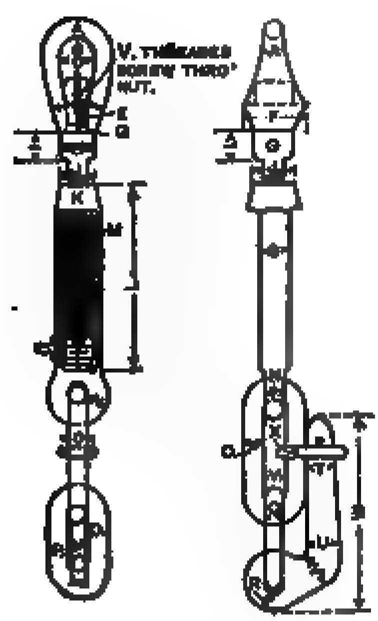
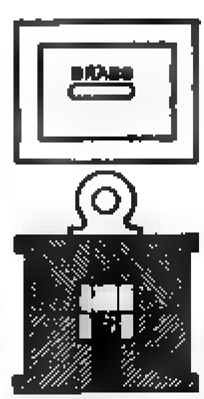


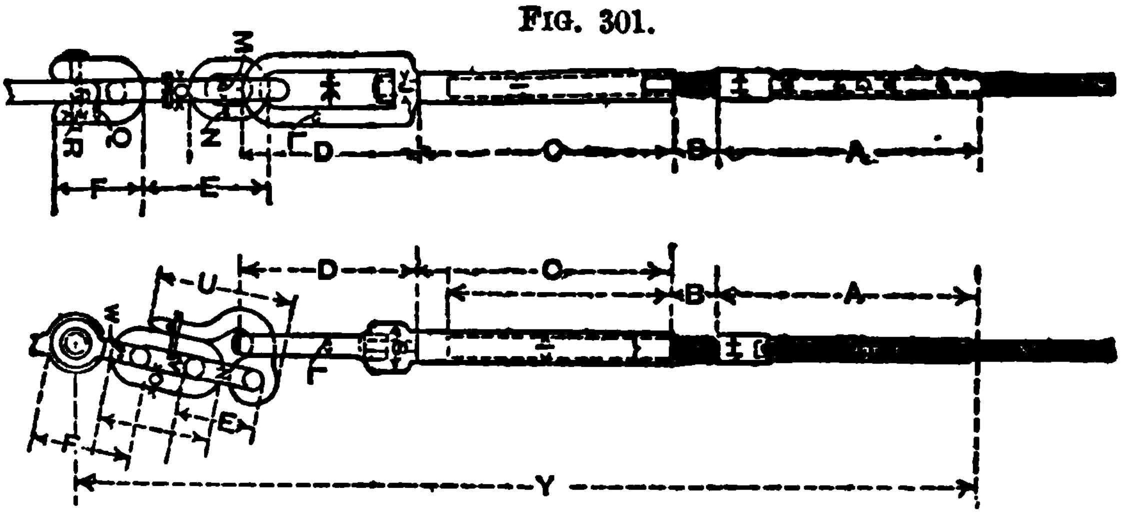
FIG. 300.



These fittings are all in proportion to the steel wire rope.

Screws, Slips, &c., for setting up Shrouds and Backstays.

Fig. 301.



	For 7 & $6\frac{1}{2}$ Steel Wire	For 6 & $5\frac{1}{2}$ Steel Wire	For 5 & $4\frac{1}{2}$ Steel Wire	For 4 & $3\frac{1}{2}$ Steel Wire	For 3 & $2\frac{1}{2}$ Steel Wire	For 2 & $1\frac{1}{2}$ Steel Wire
	Proof Strain 44 Tons	Proof Strain 36 Tons	Proof Strain 24 Tons	Proof Strain 18 Tons	Proof Strain 12 tons	Proof Strain 6 Tons
	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
A	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$
B	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{2}$	$2\frac{1}{2}$	2	$1\frac{1}{2}$
C	$4\frac{1}{8}$	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{3}{8}$	$1\frac{7}{8}$	$1\frac{3}{5}$
D	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{3}{8}$	1
E	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{3}{8}$	1
F	6	$5\frac{1}{2}$	$4\frac{3}{4}$	$3\frac{3}{4}$	$3\frac{1}{8}$	$2\frac{5}{8}$
G	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{3}{8}$	1
H	4	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{1}{2}$	2	$1\frac{1}{8}$
I	$2\frac{5}{8}$	$2\frac{3}{8}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{3}{8}$	1
J	4	$3\frac{3}{4}$	$3\frac{1}{4}$	$2\frac{1}{2}$	2	$1\frac{1}{2}$
K	$3\frac{1}{4}$	3	$2\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{4}$
L	19	17	15	$13\frac{1}{2}$	12	$10\frac{1}{2}$
M	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$
N	$1\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{5}{8}$
O	$2\frac{1}{8}$	2	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$\frac{7}{8}$
P	$2\frac{1}{4} \times 5\frac{3}{8}$	$2\frac{1}{8} \times 5$	$2 \times 4\frac{1}{2}$	$1\frac{5}{8} \times 3\frac{5}{8}$	$1\frac{3}{8} \times 3\frac{1}{2}$	$1 \times 2\frac{1}{4}$
Q	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{4}$
R	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$	1	$\frac{3}{4}$
S	$2\frac{7}{8}$	$2\frac{5}{8}$	$2\frac{3}{8}$	2	$1\frac{5}{8}$	$1\frac{1}{4}$
T	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$
U	$3\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{3}{8}$	$1\frac{3}{4}$
V	$3\frac{3}{4}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$2\frac{3}{4}$	$2\frac{3}{8}$	$1\frac{3}{4}$
W	$20 \times 1\frac{7}{8}$	$18\frac{1}{4} \times 1\frac{3}{4}$	$16\frac{1}{2} \times 1\frac{5}{8}$	$13 \times 1\frac{5}{16}$	$11\frac{1}{2} \times 1\frac{1}{8}$	$8 \times \frac{7}{8}$
X	1	$\frac{7}{8}$	$\frac{3}{4}$	$\frac{5}{8}$	$\frac{1}{2}$	$\frac{3}{8}$
Y	$2\frac{1}{2} \times 11$	$2\frac{3}{8} \times 10\frac{1}{2}$	$2\frac{1}{8} \times 9\frac{3}{4}$	$1\frac{3}{4} \times 7\frac{7}{8}$	$1\frac{3}{8} \times 7\frac{1}{2}$	$1\frac{1}{8} \times 5$
Screw	$2\frac{5}{8}$ dia. $\frac{1}{2}$ pitch	$2\frac{3}{8}$ dia. $\frac{1}{2}$ pitch	$2\frac{1}{8}$ dia. $\frac{3}{8}$ pitch	$1\frac{3}{4}$ dia. $\frac{3}{8}$ pitch	$1\frac{3}{8}$ dia. $\frac{1}{4}$ pitch	1 dia. $\frac{1}{4}$ pitch
Z	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{3}{8}$	2	$1\frac{3}{8}$	$1\frac{1}{4}$

	For $2\frac{1}{2}''$ Steel Wire		For $2\frac{1}{4}''$ Steel Wire		For $2''$ Steel Wire		For $1\frac{3}{4}''$ Steel Wire	
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.
A	1	6	1	$5\frac{5}{8}$	1	5	1	$4\frac{7}{8}$
B		$3\frac{1}{4}$		$3\frac{1}{8}$		$3\frac{1}{8}$		3
C	1	$5\frac{1}{2}$	1	$5\frac{1}{8}$	1	$4\frac{3}{4}$	1	$4\frac{5}{8}$
D	1	$0\frac{3}{8}$		$11\frac{3}{8}$		$11\frac{3}{4}$		$11\frac{1}{8}$
E		$4\frac{7}{8}$		$4\frac{3}{8}$		$4\frac{3}{8}$		$4\frac{1}{8}$
F		$6\frac{3}{8}$		6		6		$5\frac{3}{8}$
G		$1\frac{3}{8}$		$1\frac{1}{4}$		$1\frac{1}{8}$		$\frac{7}{8}$
H		$1\frac{3}{4}$		$1\frac{5}{8}$		$1\frac{1}{2}$		$1\frac{1}{8}$
I		$1\frac{7}{8}$		$1\frac{3}{4}$		$1\frac{5}{8}$		$1\frac{3}{8}$
J		$1\frac{1}{8}$		$\frac{15}{16}$		$\frac{7}{8}$		$\frac{3}{4}$
K		$2\frac{1}{8}$		2		2		$1\frac{7}{8}$
L		$1\frac{1}{8}$		$\frac{7}{8}$		$\frac{7}{8}$		$\frac{3}{4}$
M		$1\frac{3}{8}$		$1\frac{3}{8}$		$1\frac{3}{8}$		$1\frac{3}{8}$
N		$1\frac{1}{16}$		$\frac{7}{8}$		$\frac{3}{4}$		$\frac{3}{4}$
O		$1\frac{1}{16}$		$\frac{7}{8}$		$\frac{3}{4}$		$\frac{3}{4}$
P		$1\frac{5}{8}$		$1\frac{5}{8}$		$1\frac{5}{8}$		$1\frac{5}{8}$
Q		$1\frac{1}{8}$		1		$\frac{7}{8}$		$\frac{3}{4}$
R		$1\frac{1}{4}$		$1\frac{1}{8}$		1		$\frac{7}{8}$
S		$3\frac{1}{4}$		$2\frac{7}{8}$		$2\frac{5}{8}$		$2\frac{3}{8}$
T		$1\frac{3}{4}$		$1\frac{5}{8}$		$1\frac{1}{2}$		$1\frac{3}{8}$
U		$9\frac{3}{4}$		$9\frac{1}{4}$		$9\frac{1}{4}$		9
V		$1\frac{5}{8}$		$1\frac{5}{8}$		$1\frac{5}{8}$		$1\frac{5}{8}$
W		$1\frac{1}{8}$		1		$\frac{7}{8}$		$\frac{3}{4}$
X		$1\frac{1}{8}$		1		$\frac{7}{8}$		$\frac{3}{4}$
Y	5	$2\frac{1}{2}$	5	1	4	$11\frac{1}{2}$	4	11
Screw		$1\frac{3}{8}$ dia.		$1\frac{1}{4}$ dia.		$1\frac{1}{8}$ dia.		$\frac{7}{8}$ dia.

Table of Dimensions of Awning Stanchions for Admiralty Ships.

Class of Ship	Size at Top	Size at Middle	Size at Bottom	Length, about		Length from Deck to Top of Stanchion	
	Ins.	Ins.	Ins.	Ft.	Ins.	Ft.	Ins.
Admiral class, 'Rodney' . .	$2\frac{1}{2}$	$3\frac{1}{4}$	4	11	7	10	0
Belted cruisers, 'Immortalité'	$1\frac{3}{4}$	3	$3\frac{1}{2} \times 2\frac{1}{4}$	13	6	10	0
Protected cruiser 'Media'. .	$1\frac{3}{4}$	$2\frac{1}{2}$	3	12	8	10	0
Torpedo gun boats, 'Salamander' class	$1\frac{1}{2}$	2	$1\frac{3}{4}$	8	6	7	0

Table of Dimensions of Davits for Admiralty Boats.

	A Height above Skid Beams		B Over-hang		Distance between Davits		Diameter of Davits at		
							Upper Eye	Heel	Head
	Ft.	Ins.	Ft.	Ins.	Ft.	Ins.	Ins.	Ins.	Ins.
30 ft. steam cutter	9	0	6	3	22	0	8½	5	5
27 " " "	9	0	6	0	20	0	7¾	4½	4½
21 " " "	8	6	5	9	16	0	6¾	4	4
36 " launch . .	9	6	7	9	26	0	10	5¾	5¾
32 " pinnace . .	9	6	7	9	23	4	9	5¼	5¼
28 " " . .	9	3	7	6	20	8	8	4¾	4¾
30 " cutter . .	9	0	7	0	22	0	6¾	4	4
25 " " . .	8	9	6	4	18	8	6½	3¾	3¾
30 " gig . . .	8	0	5	6	22	0	6	3½	3½
25 " " . . .	8	0	5	6	18	8	5½	3¼	3¼

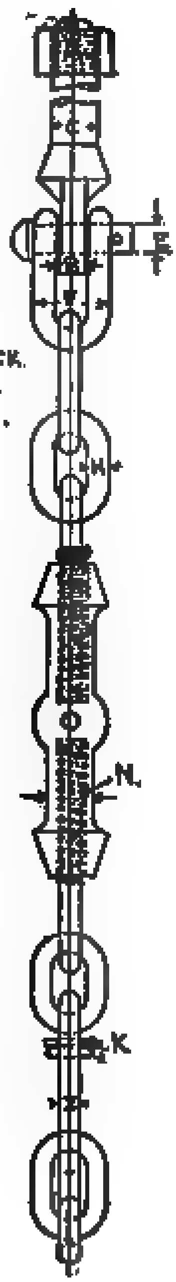
Note.—The above dimensions are only approximate, as the position and overhang of davits must in each case be decided to meet the requirements of the ship.

Table of Dimensions of Crossheads and Screw Slips for Boats' Davits. (Fig. 302.)

	32 ft. Steam Boat 36 ft. Sailing Pinnace 32-30 ft. Sailing Pinnace	27-23 ft. Steam Cutter 34-25 ft. Cutter	32 ft. Gig and other Small Boats
	Inches	Inches	Inches
A	12½	12½	10½
A_2	8¾	8½	8¼
A_3	5	4½	4
a	1⅛	1⅛	1
B	1⅜	1¼	1⅛
C	2½	2	1⅜
D	6	5½	5
E	1⅛	1⅜	1¼
F	4	3⅝	3¼
G	1¼	1⅜	1
*H	1⅝	1	⅞
I	1¼	1⅛	1
J	3½ × 1⅛	3⅛ × 1	2¼ × ⅞
K	1⅛ diam., ⅝ pitch	1¼ diam., 5-16ths pitch	1 diam., ¼ pitch
L	2¼	2	1¾
M	12	12	12
N	2½ × 3¼	2 × ⅝	1¾ × ½
O	2¼	2	1¼
P	9¾	9⅛	9
*Q	5½ × 4 × 1⅛	5 × 3½ × 1	4½ × 3 × ⅞
R	10 × 4½ × 1¼	9 × 3¾ × 1⅛	8 × 3½ × 1
S	12	11	9¾
T	2½	2½	2
U	2¼	1¾	1¼
V	6	5	4
W	1¾	1⅛	1¼
X	½ link	7-16ths link	⅜ link
Y	1¼	1⅛	1
Z	1⅜	1⅜	1

* See note on page 423.

SINGLE OR DO
BLOCK. (FIXI
OUTER.



Note.—**Steam boats and 36 feet sailing pinnaces, 1 single and 1 double block, 8½ inches diameter.**

30 feet and 32 feet sailing pinnaces, 1 single and 1 double block, 8½ inches diameter.

34 feet and 25 feet cutters, 2 single blocks, 8½ inches diameter.

32 feet gig and smaller boats, 2 single blocks, 6½ inches diameter.

* The number of links to be arranged so that the boat may be turned in while suspended by the screw-slip.

GENERAL FORM OF BLOCKS FOR ANCHOR GEAR.

FIG 303.—LEADING BLOCK.

LEADING BLOCK. TABLE OF DIMENSIONS.

Weight of Anchor	A	B	C	D	E	E₁	F	F₁	G	H	I	K	K₁
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	20	6[illegible]	6[illegible]	[illegible]	2[illegible]	2	3	2[illegible]	[illegible]	6[illegible]	1	[illegible]	21
120 ,, 106	20	6[illegible]	6[illegible]	[illegible]	2[illegible]	2	2[illegible]	2[illegible]	[illegible]	6[illegible]	1	[illegible]	21
105 ,, 91	18	6[illegible]	6	[illegible]	2	1[illegible]	2[illegible]	2[illegible]	[illegible]	6[illegible]	[illegible]	[illegible]	18[illegible]
90 ,, 76	18	6[illegible]	6	[illegible]	2	1[illegible]	2[illegible]	2	[illegible]	6[illegible]	[illegible]	[illegible]	18[illegible]
75 ,, 61	16	5[illegible]	5[illegible]	[illegible]	1[illegible]	1[illegible]	2[illegible]	1[illegible]	[illegible]	5[illegible]	[illegible]	[illegible]	16[illegible]
60 ,, 46	16	5[illegible]	5[illegible]	[illegible]	1[illegible]	1[illegible]	2	1[illegible]	[illegible]	5[illegible]	[illegible]	[illegible]	16[illegible]
44 ,, 35	14	4[illegible]	4[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	14[illegible]
34 ,, 26	12	4[illegible]	4[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]	[illegible]	12[illegible]
25 ,, 18	10	3[illegible]	3[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	3[illegible]	[illegible]	[illegible]	10[illegible]
17 ,, 12	10	3[illegible]	3[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1	[illegible]	3[illegible]	[illegible]	[illegible]	10[illegible]
11 ,, 7	9	3[illegible]	3[illegible]	[illegible]	1	1	1	[illegible]	[illegible]	3[illegible]	[illegible]	[illegible]	9[illegible]

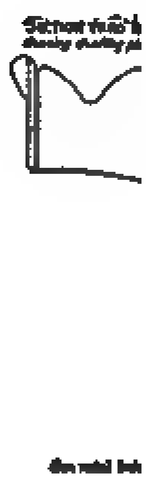
Leading Block. Table of Dimensions (*continued*).

Weight of Anchor	L	L₁	M	M₁	M₂	N	N₁	O	P	Q	R	R₁	S
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	2	5¾	1 5/16	1 9/16	6¾	¾	3½	2	2	2¾	2⅞	3½	3¼
120 „ 106	1⅞	5½	1 3/16	1 7/16	6¼	⅝	3¼	1¾	1¾	2½	2⅝	3⅛	3
105 „ 91	1¾	5¼	1 1/16	1 5/16	5⅝	½	2⅞	1⅝	1⅝	2¼	2⅜	3	2¾
90 „ 76	1⅝	4⅞	15/16	1 3/16	5	7/16	2⅞	1½	1½	2	2⅛	2¾	2½
75 „ 61	1½	4½	⅞	1 1/16	4¾	⅜	2½	1⅜	1⅜	1⅞	2	2½	2⅜
60 „ 45	1⅜	4	13/16	1	4½	⅜	2¼	1¼	1¼	1¾	1⅞	2⅜	2¼
44 „ 35	1¼	3¾	11/16	⅞	4	5/16	2	1⅛	1⅛	1½	1⅝	2	1⅞
34 „ 26	1⅛	3⅜	⅝	13/16	3½	5/16	2	1	1	1⅜	1½	1¾	1¾
25 „ 18	1	2¾	9/16	11/16	3	¼	1¾	⅞	⅞	1⅛	1¼	1⅝	1½
17 „ 12	⅞	2⅜	½	⅝	2¾	¼	1⅝	¾	¾	1	1⅛	1¼	1⅜
11 „ 7	¾	2	7/16	9/16	2½	3/16	1½	⅝	⅝	⅞	1	1⅛	1¼

Weight of Anchor	T	U	U₁	V	V₁	W	X	X₁	Y₁	Z	Z₁	*a*
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	6¼	3½	3⅜	5¼	6¼	3¼	3½	8⅝	1½ × ⅝	3¼	7½	2½
120 „ 106	6	3⅜	3¼	5	6	3⅛	2⅞	7⅞	1⅜ × ⅝	3⅛	6⅞	2½
105 „ 91	5¾	3¼	3⅛	4¾	5¾	3	2¾	7⅛	1¼ × ½	3	6½	2
90 „ 76	5½	3⅛	3	4½	5½	2⅞	2⅝	6⅝	1¼ × ½	2¾	5¾	2
75 „ 61	5	2⅞	2¾	4⅛	5	2¾	2¼	6	1⅛ × 7/16	2⅝	5¼	1¾
60 „ 45	4⅜	2⅝	2⅝	3⅝	4⅜	2½	2⅛	5⅝	1⅛ × 7/16	2⅜	4⅝	1¾
44 „ 35	4⅛	2⅜	2¼	3⅜	4	2¼	1⅞	4⅞	⅞ × ⅜	2	4	1½
34 „ 26	3¾	2⅛	2	3	3⅝	2	1⅝	4½	13/16 × ⅜	1¾	3⅝	1⅜
25 „ 18	3⅜	1⅞	1¾	2⅝	3⅛	1¾	1⅜	3¾	11/16 × 5/16	1⅝	3	1¼
17 „ 12	2⅞	1⅝	1⅜	2¼	2⅝	1½	1¼	3⅜	⅝ × ¼	1¼	2¾	1¼
11 „ 7	2½	1⅜	1¼	1⅞	2⅛	1¼	1⅛	3	½ × 3/16	1⅛	2½	1⅛

Weight of Anchor	*b*	*c*	*d*	*e*	Proof Test	Size of Catting Pendant used, F.S.W. rope	Size of Ground Chain used	Size of Chafing-piece ($f \times g$)
Cwts.	Ins.	Ins.	Ins.	Ins.	Tons	Ins.	Ins.	Ins.
135 to 121	1¼	¾	1	1¼	68	4½	1¼	1 × 2½
120 „ 106	1¼	¾	1	1¼	60	4½	1¼	1 × 2½
105 „ 91	1	⅝	⅞	1	55	4	1⅛	⅞ × 2⅛
90 „ 76	1	⅝	⅞	1	45	4	1⅛	⅞ × 2⅛
75 „ 61	⅞	½	¾	⅞	37½	3½	1	¾ × 1¾
60 „ 45	⅞	½	¾	⅞	30	3½	1	¾ × 1¾
44 „ 35	¾	½	⅝	¾	22	3	⅞	⅝ × 1½
34 „ 26	⅝	7/16	⅝	¾	17	2½	⅞	⅝ × 1¼
25 „ 18	9/16	7/16	9/16	⅝	12½	2½	¾	½ × 1⅛
17 „ 12	9/16	⅜	9/16	⅝	8½	2¼	⅝	½ × 1⅛
11 „ 7	½	⅜	½	½	5½	2	½	⅜ × 1

FIG. 304.—CATHEAD BLOCK.



CATHEAD BLOCK. TABLE OF DIMENSIONS.											
Weight of Anchor	A	B	C	D	E	E_1	F	F_1	G	H	I
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	20	6[illegible]	6[illegible]	[illegible]	2[illegible]	2	3	2[illegible]	[illegible]	6[illegible]	1
120 „ 106	20	6[illegible]	6[illegible]	[illegible]	2[illegible]	2	2[illegible]	2[illegible]	[illegible]	6[illegible]	1
105 „ 91	18	6[illegible]	6	[illegible]	2	1[illegible]	2[illegible]	2[illegible]	[illegible]	6[illegible]	[illegible]
90 „ 76	18	6[illegible]	6	[illegible]	2	1[illegible]	2[illegible]	2	[illegible]	6[illegible]	[illegible]
75 „ 61	16	6[illegible]	5[illegible]	[illegible]	1[illegible]	1[illegible]	2[illegible]	1[illegible]	[illegible]	6[illegible]	[illegible]
60 „ 45	16	5[illegible]	5[illegible]	[illegible]	1[illegible]	1[illegible]	2	1[illegible]	[illegible]	5[illegible]	[illegible]
44 „ 35	14	4[illegible]	4[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]
34 „ 26	12	4[illegible]	4[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	4[illegible]	[illegible]
25 „ 18	10	3[illegible]	3[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1[illegible]	[illegible]	3[illegible]	[illegible]
17 „ 12	10	3[illegible]	3[illegible]	[illegible]	1[illegible]	1[illegible]	1[illegible]	1	[illegible]	3[illegible]	[illegible]
11 „ 7	9	3[illegible]	3[illegible]	[illegible]	1	1	1	[illegible]	[illegible]	3[illegible]	[illegible]

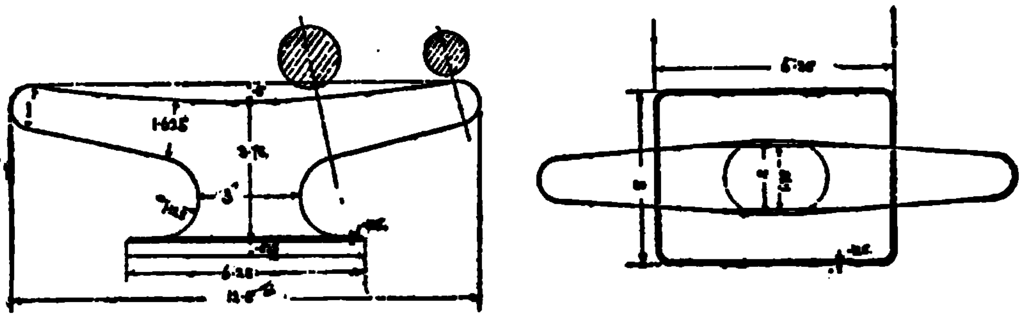
CATHEAD BLOCK. TABLE OF DIMENSIONS (*continued*).

Weight of Anchor	K	K_1	L	L_1	M	M_1	M_2	N	N_1	O	P
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	1/2	21	2	5 3/4	1 5/16	1 9/16	6 3/4	3/4	3 1/4	2	2
120 „ 106	1/2	21	1 7/8	5 1/2	1 3/16	1 7/16	6 1/4	5/8	3 1/4	1 3/4	1 3/4
105 „ 91	7/16	18 3/4	1 3/4	5 1/4	1 1/16	1 5/16	5 5/8	1/2	2 7/8	1 5/8	1 5/8
90 „ 76	7/16	18 3/4	1 5/8	4 7/8	15/16	1 3/16	5	7/16	2 7/8	1 1/2	1 1/2
75 „ 61	3/8	16 1/2	1 1/2	4 1/2	7/8	1 1/16	4 3/4	3/8	2 1/2	1 3/8	1 3/8
60 „ 45	3/8	16 1/2	1 3/8	4	13/16	1	4 1/2	3/8	2 1/2	1 1/4	1 1/4
44 „ 35	5/16	14 1/2	1 1/4	3 1/2	11/16	7/8	4	5/16	2	1 1/8	1 1/8
34 „ 26	5/16	12 3/8	1 1/8	3 1/4	5/8	13/16	3 1/2	5/16	2	1	1
25 „ 18	1/4	10 3/8	1	2 3/4	9/16	11/16	3	1/4	1 3/4	7/8	7/8
17 „ 12	1/4	10 3/8	7/8	2 3/8	1/2	5/8	2 3/4	1/4	1 3/4	3/4	3/4
11 „ 7	3/16	9 1/4	3/4	2	7/16	9/16	2 1/2	3/16	1 1/2	5/8	5/8

Weight of Anchor	Q	R	S	T	U	V	W	Z	*a*	*b*	*c*
Cwts.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
135 to 121	2 3/4	2 3/4	3 1/8	3 1/8	3 1/4	3 1/4	10 1/2	1/2	2 1/2	1 1/4	3/4
120 „ 106	2 1/2	2 1/2	2 7/8	2 7/8	3 1/8	3 1/8	10	1/2	2 1/2	1 1/4	3/4
105 „ 91	2 1/4	2 1/4	2 5/8	2 5/8	3	3	9 1/2	1/2	2	1	5/8
90 „ 76	2	2	2 3/8	2 3/8	2 3/4	2 3/4	8 1/2	3/8	2	1	5/8
75 „ 61	1 7/8	1 7/8	2 1/4	2 1/4	2 1/2	2 1/2	7 1/2	3/8	1 3/4	7/8	1/2
60 „ 45	1 3/4	1 3/4	2 1/8	2 1/8	2 1/4	2 1/4	6 1/2	3/8	1 3/4	7/8	1/2
44 „ 35	1 1/2	1 1/2	1 3/4	1 3/4	2 1/8	2 1/8	5 3/4	3/8	1 1/2	3/4	1/2
34 „ 26	1 3/8	1 3/8	1 5/8	1 5/8	2	2	5	5/16	1 3/8	5/8	7/16
25 „ 18	1 1/8	1 1/8	1 3/8	1 3/8	1 3/4	1 3/4	4 1/4	5/16	1 1/4	9/16	7/16
17 „ 12	1	1	1 1/4	1 1/4	1 1/2	1 1/2	3 1/2	1/4	1 1/4	9/16	3/8
11 „ 7	7/8	7/8	1	1	1 1/4	1 1/4	2 3/4	1/4	1 1/8	1/2	3/8

Weight of Anchor	*d*	*e*	Proof Test	Size of Catting Pendant used, F.S.W. rope	Size of Ground Chain used	Size of Chafing piece ($f \times g$)
Cwts.	Ins.	Ins.	Tons	Ins.	Ins.	Ins.
135 to 121	1	1 1/4	68	4 1/2	1 1/4	1 × 2 1/2
120 „ 106	1	1 1/4	60	4 1/2	1 1/4	1 × 2 1/2
105 „ 91	7/8	1	55	4	1 1/8	7/8 × 2 1/8
90 „ 76	7/8	1	45	4	1 1/8	7/8 × 2 1/8
75 „ 61	3/4	7/8	37 1/2	3 1/2	1	3/4 × 1 3/4
60 „ 45	3/4	7/8	30	3 1/2	1	3/4 × 1 3/4
44 „ 35	3/4	3/4	22	3	7/8	5/8 × 1 1/2
34 „ 26	5/8	3/4	17	2 1/2	7/8	5/8 × 1 1/2
25 „ 18	9/16	5/8	12 1/2	2 1/4	3/4	5/8 × 1 1/8
17 „ 12	9/16	5/8	8 1/2	2 1/4	5/8	5/8 × 1 1/8
11 „ 7	1/2	1/2	5 1/2	2	1/2	5/8 × 1

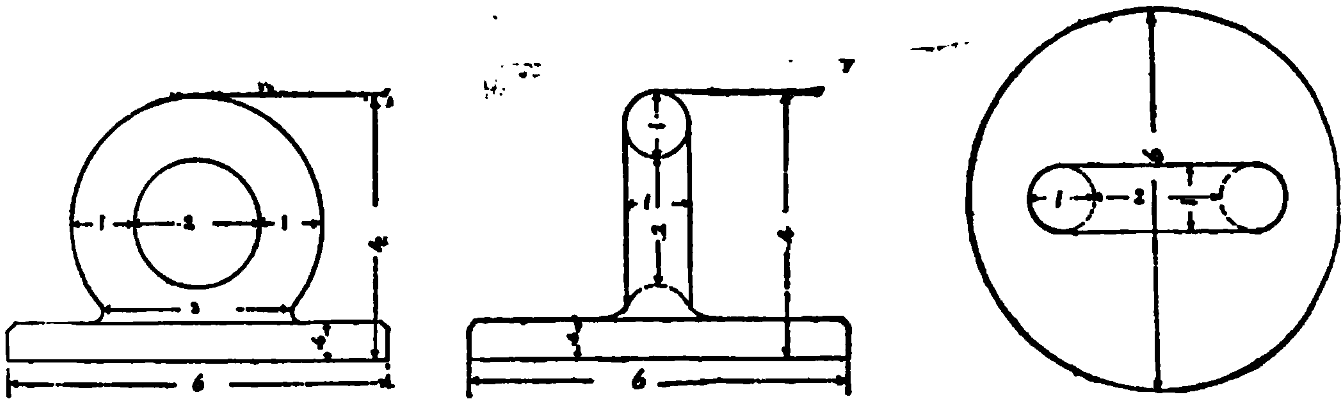
FIG. 305.—WROUGHT-IRON CLEAT.



Diameter of rope = $2\frac{1}{2}$ inches.

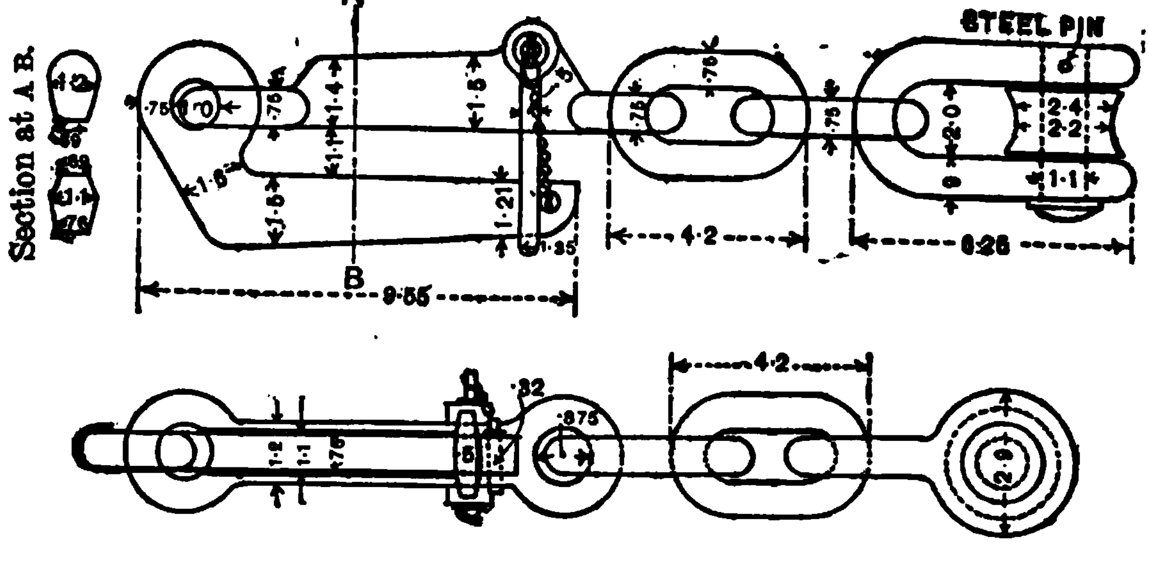
Note.—The dimensions given are multiples of the diameter at the tip.

FIG. 306.—EYE-PLATE FOR GENERAL PURPOSES.



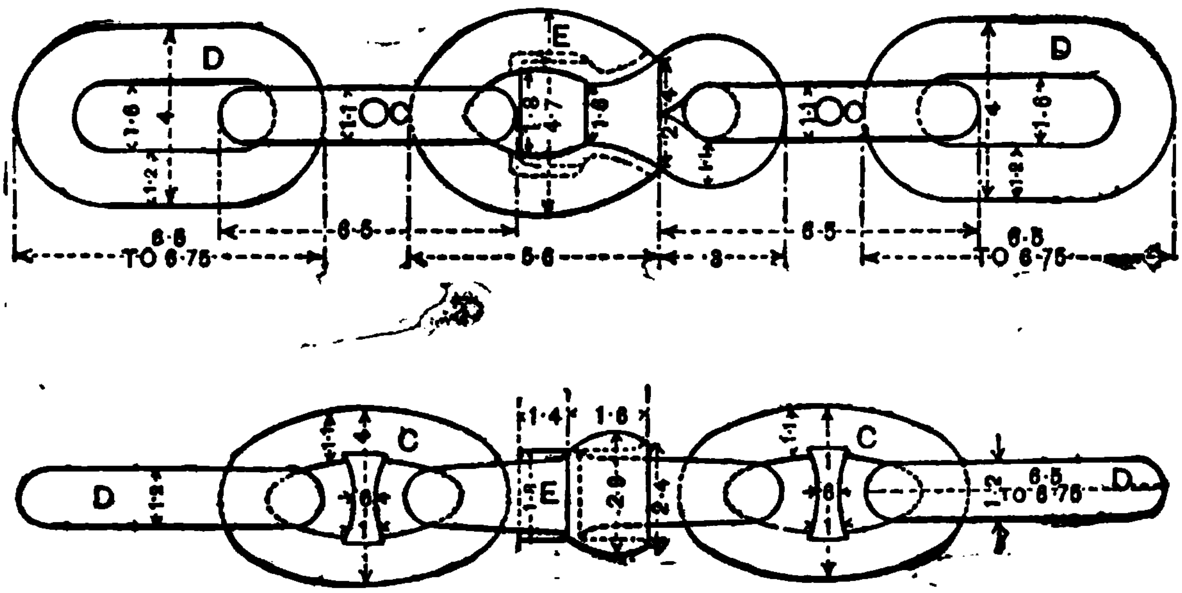
Note.—The dimensions given are multiples of the eye.

FIG. 307.—CLEAR HAWSE SLIP.



Note.—The dimensions given are multiples of the eye.

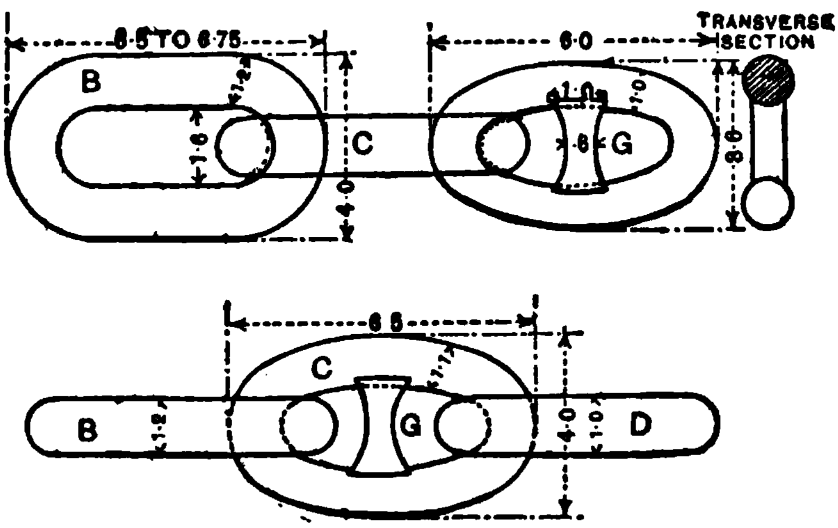
FIG. 308.—SWIVEL-PIECE.



C C, enlarged links (with stay-pins).
D D, end links.
E, swivel.

Note.—The dimensions given are multiples of the diameter of the cable.

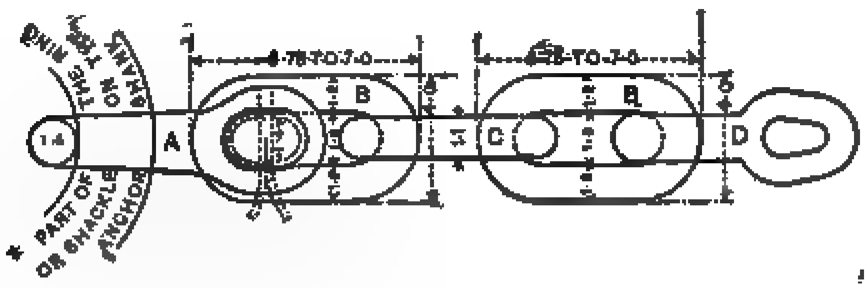
FIG. 309.—END LINK, ENLARGED LINK (WITH STAY-PIN), AND COMMON LINK OF CHAIN CABLE.



B, end link (without stay-pin).
C, enlarged link (with stay-pin).
D, common link.
G, stay-pin.

Note.—The dimensions given are multiples of the diameter of the cable.

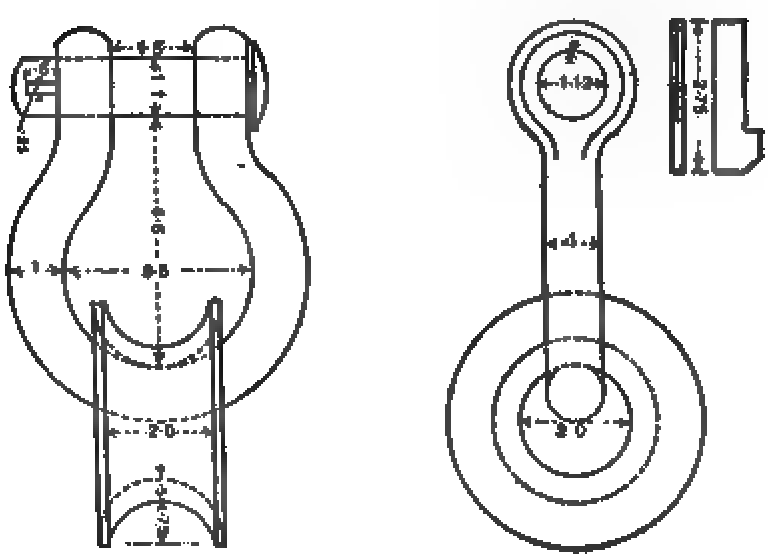
FIG. 310.—ANCHOR SHACKLE, INTERMEDIATE PIECE, AND JOINING SHACKLE.



A, large or anchor shackle.
B, end links of intermediate piece (without stay-pins).
C, enlarged link in centre of intermediate piece (with stay-pin).
D, joining shackle (fig. 292).
a, b, see page 431.
x, y, tinned steel pin through bolt and forelock, secured with lead pellet.

Note.—The dimensions given are multiples of the diameter of the cable.

FIG. 311.—DECK STOPPER SHACKLE.



Note.—The dimensions given are multiples of the iron of the shackle.

TABLE GIVING WIDTH OF LARGE (OR ANCHOR) SHACKLE

Diameter of Cable	Width of Anchor Shackle in the clear (a, b, fig. 310)	Diameter of Cable	Width of Anchor Shackle in the clear (a, b, fig. 310)
Inches	Inches	Inches	Inches
3	$9\frac{1}{2}$	$1\frac{1}{2}$	$4\frac{1}{2}$
$2\frac{3}{4}$	$8\frac{1}{2}$	$1\frac{3}{8}$	$4\frac{1}{4}$
$2\frac{9}{16}$	$7\frac{3}{4}$	$1\frac{1}{4}$	4
$2\frac{1}{2}$	$7\frac{1}{2}$	$1\frac{1}{8}$	$3\frac{1}{2}$
$2\frac{3}{8}$	7	1	$3\frac{1}{4}$
$2\frac{1}{4}$	$6\frac{1}{2}$	$\frac{7}{8}$	3
$2\frac{1}{8}$	6	$\frac{3}{4}$	3
2	$5\frac{1}{2}$	$\frac{11}{16}$	$2\frac{1}{2}$
$1\frac{7}{8}$	$5\frac{1}{8}$	$\frac{5}{8}$	$2\frac{1}{8}$
$1\frac{3}{4}$	$4\frac{3}{4}$	$\frac{1}{2}$	$1\frac{1}{2}$
$1\frac{5}{8}$	$4\frac{5}{8}$	—	—

TABLE OF TESTS FOR DECK STOPPER SHACKLES

Size of Shackle in inches	Proof Test in tons	Size of Shackle in inches	Proof Test in tons
1	5	$1\frac{7}{8}$	$17\frac{5}{8}$
$1\frac{1}{8}$	$6\frac{3}{8}$	2	20
$1\frac{1}{4}$	$7\frac{7}{8}$	$2\frac{1}{8}$	$22\frac{5}{8}$
$1\frac{3}{8}$	$9\frac{1}{2}$	$2\frac{1}{4}$	$25\frac{3}{8}$
$1\frac{1}{2}$	$11\frac{1}{4}$	$2\frac{3}{8}$	$28\frac{1}{4}$
$1\frac{5}{8}$	$13\frac{1}{4}$	$2\frac{1}{2}$	$31\frac{1}{4}$
$1\frac{3}{4}$	$15\frac{3}{8}$	$2\frac{9}{16}$	$32\frac{7}{8}$

Note.—The breaking strains of the several sizes of shackles are not to fall short of the above proof strains, with 50 per cent. added.

Table of Dimensions of Capstan Bars.

Pattern No. 1.—From 16 ft. to 14 ft. long—5¼ in. square for a length of 20 in. from inner end, tapered to 3¾ in. at the outer end.

Pattern No. 1A.—From 13 ft. to 11 ft. long—4¾ in. for a length of 16 in. from inner end, tapered to 3½ in. to the outer end.

Pattern No. 1B.—From 10 ft. to 8 ft. long—4 in. square for a length of 12 in. from inner end, tapered to 3 in. at outer end.

Pattern No. 1C.—From 7 ft. to 6 ft. long—3½ in. square for a length of 12 in. from inner end, tapered to 2½ in. at outer end.

Size of Seamen's Lockers.

The internal capacity of the portable lockers for seamen's clothes is to be 4 cubic feet at least, and for fixed lockers for seamen's clothes from 4 to 5 cubic feet.

Compressors.

The length to be 1¼ the size of the hole from the side of the pipe to the centre of the eye, to be taken when the compressor is in contact with the chain or when on athwartship line.

The size of the iron at the largest part to be not less than twice the diameter of the link of the chain in breadth, ⅝ the breadth to be the depth, and the outer end to be ⅝ the size of the largest end.

Class of Ship	Sizes at Large Ends		Sizes at Small Ends		Diam. of Bolt
	Broad	Deep	Broad	Deep	
Ships of the line—	Ins.	Ins.	Ins.	Ins.	Ins.
2⅛" to 2" chain	4½	3	3	2	2¼
Frigates—1⅞" to 1¾"	3¾	2½	2½	1¾	2⅛
" 1⅝"	3¼	2⅛	2⅛	1½	1⅞
Corvettes and sloops—					
400 to 600 tons 1½ to 1¾	3	2	2	1⅜	1¾
300 to 400 tons	2½	1¾	1¾	1¼	1½
Under 300 tons	2¼	1¾	1⅜	1	1⅜

LENGTH OF ROLLER REQUIRED TO 100 FATHOMS OF HEMPEN ROPE.
(Diam. of Roller, $4\frac{1}{2}''$; Wheels, 24″ and 30″ respectively.)

Diam. of Roller	Size of Rope	Diam. of Wheel	Length of One Single Coil Ft.	In.	Diam. of Rope	Length of Roller
Inches	Inches	Inches	Ft.	In.	Inches	Inches
$4\frac{1}{2}$	$3\frac{1}{2}$	24	34	0	$1\frac{1}{8}$	20
$4\frac{1}{2}$	$3\frac{1}{2}$	30	55	6	$1\frac{1}{8}$	13
$4\frac{1}{2}$	4	24	30	0	$1\frac{1}{4}$	25
$4\frac{1}{2}$	4	30	49	0	$1\frac{1}{4}$	16
$4\frac{1}{2}$	$4\frac{1}{2}$	24	25	0	$1\frac{7}{16}$	35
$4\frac{1}{2}$	$4\frac{1}{2}$	30	43	0	$1\frac{7}{16}$	20
$4\frac{1}{2}$	5	24	23	0	$1\frac{5}{8}$	43
$4\frac{1}{2}$	5	30	38	4	$1\frac{5}{8}$	27
$4\frac{1}{2}$	$5\frac{1}{2}$	24	22	6	$1\frac{3}{4}$	51
$4\frac{1}{2}$	$5\frac{1}{2}$	30	31	6	$1\frac{3}{4}$	35
$4\frac{1}{2}$	6	24	22	0	$1\frac{7}{8}$	59
$4\frac{1}{2}$	6	30	25	0	$1\frac{7}{8}$	43
$4\frac{1}{2}$	$6\frac{1}{2}$	24	19	0	2	63
$4\frac{1}{2}$	$6\frac{1}{2}$	30	27	0	2	46
$4\frac{1}{2}$	7	24	18	0	$2\frac{1}{8}$	70
$4\frac{1}{2}$	7	30	26	0	$2\frac{1}{8}$	50
$4\frac{1}{2}$	$7\frac{1}{2}$	24	18	0	$2\frac{1}{4}$	75
$4\frac{1}{2}$	$7\frac{1}{2}$	30	26	0	$2\frac{1}{4}$	53
$4\frac{1}{2}$	8	24	17	9	$2\frac{7}{16}$	80
$4\frac{1}{2}$	8	30	27	0	$2\frac{7}{16}$	55

TABLE OF THE WEIGHT AND STRENGTH OF SAIL CANVAS IN LBS. PER BOLT OF 24 INS. WIDE.

No. of canvas . . .	0	1	2	3	4	5	6	7	8
Length of bolt (yards) .	39	39	39	39	39	39	39	40	40
Weight of bolt (lbs.) . .	48	46	43	40	36	33	30	27	25
Tenacity in lbs. (weft) .	—	480	460	440	400	370	350	390	380
Tenacity in lbs. (warp) .	—	340	320	300	280	260	250	330	310

TABLE OF THE NUMBER OF CUBIC FEET REQUIRED TO STOW 100 FATHOMS OF CHAIN CABLE.

Diam. of chain (ins.)	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
No. of cubic feet	14	17	20	23	27	31	35	44	55
Diam. of chain (ins.)	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$	2	$2\frac{1}{8}$	$2\frac{1}{4}$	$2\frac{1}{2}$
No. of cubic feet	66	79	92	107	123	140	158	177	218

Size of Baths.

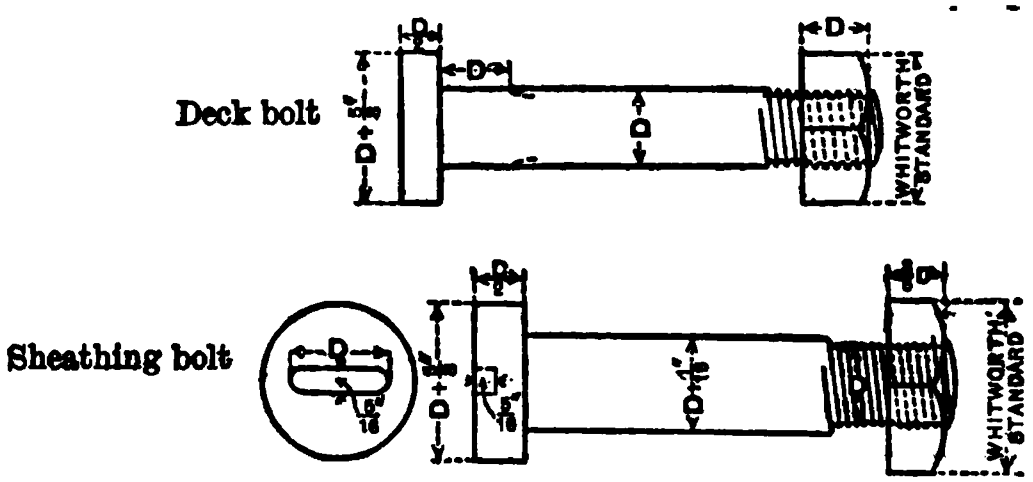
	Length ft.	Length in.		Breadth ft.	Breadth in.	Breadth ft.	Breadth in.	Depth ft.	Depth in.
At top	5	4	. .	1	10	1	4½	1	10¼
At bottom	4	2½	. .	1	4½	1	2½		

Deck Bolts.

Screw-bolts of $\frac{3}{16}''$ diameter, with hexagonal or square heads and nuts, are to conform to Whitworth's standard gauges for nuts and bolts of the respective sizes, and are to be round under the heads. The diameter of square heads and nuts is to be reckoned across the sides, the same as for the hexagonal form. Bolts with round heads—deck bolts—are to have hexagonal nuts, the nuts to conform to Whitworth's standard gauges for the respective sizes; the diameter of the heads to be $\frac{5}{8}''$ more than that of the bolt, and the thickness of the heads to be half the diameter of the bolt. These bolts to be square under the head for a distance equal to the diameter of the bolt.

Bolt heads to be let into deck $\frac{1}{3}$ the thickness of deck screw-bolts, wrought iron, $\frac{7}{8}''$ to $1\frac{1}{4}''$, for fastening the wood sheathing of iron ships; diameter of bolt to be measured over screw part; plain part to be $\frac{1}{16}''$ larger, and round under the head. Heads to be round, of a diameter $\frac{5}{8}''$ greater than the diameter of bolt; thickness of head to be half the diameter of bolt. The head is to contain a slot equal in length to the diameter of the bolt, and of a breadth and depth of $\frac{5}{16}''$ for all diameters of bolts. Nuts to conform as to diameter to Whitworth's standard gauges for the respective sizes, but the thickness to be in all cases $\frac{3}{5}$ of the diameter of bolt.

Fig. 312.



The screwed part is to be truly concentric with the head and plain part, for screwing into metal through wood without enlarging the hole in the latter.

The screwing of all the above descriptions of bolts is to be Whitworth's standard thread.

SEASONING TIMBER.

Natural Seasoning.

THIS is performed by exposing the timber freely to the air in a dry place sheltered from the wind and sun, and so stacked as to admit of the air passing freely over all the surfaces of the pieces. Timber for carpenter's work will require about two years to season it properly; for joiner's work, about four years, or even longer.

Seasoning by a Vacuum.

The timber is placed in a chamber from which the air is exhausted, heat being at the same time employed so as to vaporise the exuded juices, the vapour being conveyed away by means of pipes surrounded by cold water.

Seasoning by Hot Air (Davidson).

The timber is placed in a chamber and exposed to a current of hot air impelled by a fan at the rate of about 100 feet per second, the air passages, fan, and chamber being so arranged that one-third of the volume of air in the chamber is blown through it per minute.

The temperature of the hot air varies for different kinds of timber as follows:—

Oak of any dimensions .	105° F.
Bay mahogany 1″ boards .	280°–300°
Leaf woods in logs . .	90°–100°
Pine woods in thick pieces	120°

Water Seasoning.

This is done by immersing the timber in water—if shallow and salt it is better than fresh—and letting it remain there for periods averaging from 10 to 20 years, but it is sometimes only allowed to remain 14 days, when it is taken out and stood upright in some sheltered place where the air can get at it thoroughly, so as to render it quite dry. Sometimes it is thoroughly boiled or steamed for a day or two instead of being immersed in cold water for longer periods. All these processes tend rather to injure the strength of the wood, making it softer, although it tends to prevent cracking, warping, and shrinking.

Note.—Slowly seasoned timber is tougher and more elastic than when it is rapidly dried.

Seasoning by heat alone is very injurious to timber, as it produces a hard crust on the surface and prevents the moisture from evaporating.

For joiner's work and carpentry natural seasoning should have the preference.

PRESERVING TIMBER.

CREOSOTING. (*Bethell.*)

THE timber is first well dried, either by being freely exposed to the thorough circulation of the air or dried in an oven at a temperature varying from 90° to 100° Fahr., depending on the kind of timber.

One process is then to place the timber in a strong iron cylinder, and subject it to a vacuum of 6 to 12 lbs. per square inch for 30 or 40 minutes. The creosote is then allowed to flow in, and a pressure put upon it, varying from 100 to 150 lbs. per square inch, for about 1 to 2½ hours. The other process consists in simply immersing the timber in an open tank containing hot creosote, the temperature being kept up to about 120° to 150° Fahr., and left for some time to the natural process of absorption.

Note.—Ordinary fir timber absorbs from 8 to 10 lbs. of creosote per cubic foot of timber; red pine, from 15 to 16 lbs.; memel, from 10 to 12 lbs.; oak, from 4 to 5 lbs. This method of preserving timber is the most generally used; it is a sure preventive against the attack of the teredo and other marine worms.

IMPREGNATION WITH METALLIC SALTS.

Kyan's Process.

This consists in immersing the timber in a solution of bichloride of mercury diluted with about 100 to 150 parts of water, or about 1 to ⅔ of a lb. of the salt to 10 gallons of water. Twenty-four hours are usually allowed for each inch in thickness for boards, &c.

Margary's Process.

Margary employed sulphate of copper diluted with about 40 to 50 parts of water, applied with pressure varying from 15 to 30 lbs. per square inch for 6 or 8 hours.

Burnett's Process.

A solution of about 1 lb. of chloride of zinc to 4 or 5 gallons of water is injected and applied with a pressure varying from 100 to 120 lbs. per square inch for about 15 minutes. The timber is then taken out and allowed to dry for about 14 days. The timber should remain immersed for about 2 days for every inch in thickness.

Payne's Process.

Payne's process consists in impregnating the timber with a strong solution of sulphate of iron, and afterwards forcing in a solution of any of the carbonate alkalies.

TIMBER MEASURE.

In estimating quantities of timber duodecimals are usually employed—that is, the foot, inch, seconds, &c., are each divided into twelve parts instead of ten, as in common decimal fractions; so that by this means feet, inches, and seconds can be directly multiplied by feet, inches, and seconds. Thus:—

12 inches make 1 foot.	12 thirds make 1 second.
12 seconds make 1 inch.	12 fourths make 1 third.

And—

Feet multiplied by feet give feet.
Feet multiplied by inches give inches.
Feet multiplied by seconds give seconds.
Inches multiplied by inches give seconds.
Inches multiplied by seconds give thirds.
Seconds multiplied by seconds give fourths, &c.

To Multiply by Duodecimals.

Rule.—Place the several denominations of the multiplier directly under the corresponding denominations of the multiplicand.

Then multiply each denomination in the multiplicand by the number of feet in the multiplier, and place each product under its corresponding denomination in the multiplicand, always carrying one for every twelve.

In the same manner multiply by the number of inches, and set each product one place farther to the right hand.

Then multiply by the number of seconds, and set each product another place farther to the right hand.

Thus proceed with all the other denominations, and the sum of all the products will be the whole product required.

Example 1.

Multiply 3 ft. 6½ ins. by 2 ft. 5¼ ins.

	ft.	ins.	secs.		
	3	6	6		
	2	5	3		
	7	1	0		
	1	5	8	6	
			10	7	6
Ans.	8	7	7	1	6

Example 2.

Multiply 2 ft. 7 ins. 4. secs. 8 thirds by 1 ft. 2 ins. 3 secs. 3 thirds.

	ft.	ins.	secs.	thrds.			
	2	7	4	8			
	1	2	3	3			
	2	7	4	8			
		5	2	9	4		
			7	10	2	0	
				7	10	2	0
Ans.	3	1	2	11	4	2	0

To Find the Solid Contents of Round or Unsquared Timber.

Rule 1.—Multiply the square of the quarter-girt by the length, and the product will be the solid contents.

Rule 2.—Find the area in the following table which corresponds to the quarter-girt in inches, and multiply it by the length of the timber in feet; the product will be the solid contents in cubic feet and decimals of a cubic foot.

Examples.

What is the solid contents of a tree whose girt is 60 inches and whose length is 18 feet?

By Rule 1.

	ft.	ins.	secs.
4)60			
ins. 15 =	1	3	
	1	3	
	1	3	
		3	9
ft.	1	6	9

	ft.	ins.	secs.
	18	0	0
	1	6	9
	18	0	0
	9	0	0
	1	1	6
Ans.	28	1	6

By Rule 2.

4)60
15 ins.

Corresponding to 15 ins. in the table is 1·562 feet, and

	sq. ft.
	1·562
	18
	12496
	1562
Ans.	28·112

Table of Constants for Measuring Timber.

Girt/4 Ins.	Area. Sq. Ft.	Girt/4 Ins.	Area. Sq. Ft.	Girt/4 Ins.	Area. Sq. Ft.	Girt/4 Ins.	Area. Sq. Ft.	Girt/4 Ins.	Area. Sq. Ft.
6	·250	9¾	·660	13½	1·266	17¼	2·066	24	4·000
6¼	·271	10	·694	13¾	1·313	17½	2·127	24½	4·168
6½	·293	10¼	·730	14	1·361	17¾	2·188	25	4·340
6¾	·316	10½	·766	14¼	1·410	18	2·250	25½	4·516
7	·340	10¾	·803	14½	1·460	18½	2·377	26	4·694
7¼	·365	11	·840	14¾	1·511	19	2·507	26½	4·877
7½	·391	11¼	·879	15	1·562	19½	2·641	27	5·063
7¾	·417	11½	·918	15¼	1·615	20	2·778	27½	5·252
8	·444	11¾	·959	15½	1·668	20½	2·918	28	5·444
8¼	·473	12	1·000	15¾	1·723	21	3·063	28½	5·641
8½	·502	12¼	1·042	16	1·778	21½	3·210	29	5·840
8¾	·532	12½	1·085	16¼	1·834	22	3·361	29½	6·043
9	·563	12¾	1·129	16½	1·891	22½	3·516	30	6·250
9¼	·594	13	1·174	16¾	1·948	23	3·674	31	6·674
9½	·626	13¼	1·219	17	2·007	23½	3·835	32	7·111

Timber Measures.

40 cubic feet of unhewn timber					= 1 load.
50 „ „ squared „					= 1 load.
600 superficial feet of 1-inch planks or deals					= 1 load.
400	„	„	$1\frac{1}{2}$	„ „	= 1 load.
300	„	„	2	„ „	= 1 load.
240	„	„	$2\frac{1}{2}$	„ „	= 1 load.
200	„	„	3	„ „	= 1 load.
170	„	„	$3\frac{1}{2}$	„ „	= 1 load.
150	„	„	4	„ „	= 1 load.

100 „ „ make 1 square of boarding, flooring, &c.
120 deals = 1 hundred.
Battens are 7 ins. wide, deals 9 ins., and planks 11 ins.

Waste on Converting Timber.

African oak	= 100 per cent.	English oak	= 200 per cent.
American elm	= 15 „	„ „ plank	= 50 „
Dantzic fir plank	= 25 „	Greenheart	= 25 „
„ oak	= 50 „	Mahogany	= 30 „
„ „ plank	= 40 „	Quebec oak	= 10 „
English elm	= 200 „	Teak	= 15 „

Dantzic fir, when cut from planks . . = 10 per cent.
Yellow pine, when cut for head and stern work = 200 „
„ „ „ decks . . . = 10 „

Plastering.

	1 In. Thick.	$\frac{3}{4}$ In. Thick.	$\frac{1}{2}$ In. Thick.
1 bushel of cement will cover	$1\frac{1}{4}$ sup. yd.,	$1\frac{1}{2}$ sup. yd.,	$2\frac{1}{4}$ sup. yds.
1 do. and 1 of sand „	$2\frac{1}{4}$ sup. yds.,	3 sup. yds.,	$4\frac{1}{2}$ „
1 „ 2 „ „	$3\frac{1}{4}$ „	$4\frac{1}{2}$ „	$6\frac{3}{4}$ „
1 „ 3 „ „	$4\frac{1}{2}$ „	6 „	9 „

1 cubic yd. of lime, 2 yds. of sand, and 3 bushels of hair will cover . . { 75 sup. yds. on brick. / 70 „ „ earth. / 60 „ „ laths.

Bricklaying.

	Size in Ins.	Weight in Lbs.
London stock bricks	$8\frac{3}{4} \times 4\frac{1}{4} \times 2\frac{3}{4}$	6·81
Red kiln . .	ditto.	7·00
Welsh fire . .	$9 \times 4\frac{1}{2} \times 2\frac{3}{4}$	7·84
Paving . . .	$9 \times 4\frac{1}{2} \times 1\frac{3}{4}$	5·00
Square tiles . .	$9\frac{3}{4} \times 9\frac{3}{4} \times 1$	5·70
„ . .	$6 \times 6 \times 1$	2·16

Expansion in Length of Metals, &c., by Heat per Degree Fahrenheit from 32°.

Fire-bricks	·00000235	Copper	·0000101
Stock bricks	·00000306	Bronze and gun-metal	·0000104
Granite	·00000439	Brass	·0000106
Glass	·00000460	Gold	·0000108
Platinum	·00000484	Silver	·0000112
Antimony	·00000617	Tin	·0000132
Cast iron	·00000650	White solder	·0000143
Steel	·00000668	Lead	·0000159
Wrought iron	·00000681	Zinc	·0000173
Iron wire	·00000745	Ice, from −17° to +30°	·0000286
Bismuth	·00000762		
Roman cement	·0000080		

Melting-points of Metals, &c.

Metals	Melts at	Metals	Melts at
	° Fahr.		° Fahr.
Aluminium	1300	Lead	620
Antimony	810	Mercury	39
Beeswax, white	154	Nickel	2810
„ yellow	142	Phosphorus	109
Bismuth	507	Platinum	3080
Brass	1650	1 Snow and 1 salt	0
Bronze	1690	Stearine 109 to	120
Cadmium	442	Steel, maximum	2552
Copper	2050	„ minimum	2372
Gold, coin	2156	Silver, pure	1830
„ pure	2282	Sulphur	239
Gun-metal	1850	Tallow	92
Iron, cast	2190	Tin	446
„ wrought	2912	Zinc	773

Proportions for Mixing Paint.

—	Black	White	Raw Linseed Oil	Boiled Linseed Oil	Spirits of Turpentine	Litharge
	Lbs.	Lbs.	Galls.	Galls.	Galls.	Lbs.
Outside . . .	112	—	$2\frac{1}{2}$	$2\frac{1}{2}$	$\frac{1}{4}$	6
„	—	112	$3\frac{3}{4}$	—	$\frac{1}{4}$	4
Upper-deck weather work .	—	112	$2\frac{1}{8}$	—	$1\frac{1}{8}$	4
Between decks, cabins, boats, &c.	—	112	$1\frac{3}{4}$	—	$1\frac{3}{8}$	4

Good Dryers for Coloured Paints.

3 galls. of linseed oil, 1 lb. of manganese, 1 lb. of red lead, 1 lb. of litharge. To be left for three hours.

Distemper.

112 lbs of whiting, 28 lbs. of dry white lead, 7 lbs. of glue. To be mixed with boiling water.

Hammock Cloths.

46 lbs. black, $3\frac{1}{2}$ galls. of boiled linseed oil.
2 lbs. litharge will paint about 100 yards running measure.
1 lb. white paint will cover about 3 square yards.
1 lb. black „ „ „ „ 6 „ „

Harmony of Colours.

Red looks well with white, black, or yellow.
Blue „ „ „ white or yellow.
Green „ „ „ black, white, or yellow.
Gold „ „ „ white, black, brown, blue, purple, and pink.

Mixing Paints.

White lead and lamp black mixed together make an ash colour.

White lead and ochre make the colour of new timber.
Yellow ochre and white lead make a buff colour.
White lead, vermilion, and lake make a flesh colour.
Lake and white make a carnation.
Yellow ochre and red lead make an orange.

Red lead, yellow ochre, and a little white make a brick-colour.

Burnt umber and white make a walnut-tree colour.

Yellow spruce, white lead, and a little black or burnt umber make a stone-colour.

This and experience will show the result of many other colours.

1 lb. of verdigris to 3 lbs. of white lead.
1 „ mineral „ 2 „ „ „
1 „ Antwerp „ $1\frac{1}{2}$ „ „ „

28 lbs of white lead
1 lb. of litharge
6 pints of linseed oil
2 „ turpentine
} will cover about 100 superficial yards.

28 lbs. of black paint
1 lb. of litharge
10 pints of linseed oil
2 „ turpentine
} will cover about 160 superficial yards.

46 lbs. of black
$3\frac{1}{2}$ galls. of linseed oil
2 lbs. of litharge
} will paint about 100 yards (running measure) of hammock cloths.

1 lb. of white paint will cover about 5 square yards.
1 lb. of black paint (thin) will cover about 7 square yards.

WEIGHT OF OAKUM AND PITCH, IN LBS., REQUIRED FOR EVERY 100 FEET OF SEAM IN LENGTH.

Materials	Decks	Top Sides	Wales, Channel, and Middle	Main Wales	Bottom
Oakum—					
Very slack seams . .	8	8	11	15	8
Ordinary slack seams . .	5	5	7	10	5
Pitch—					
Middling-sized seams . .	$24\frac{1}{2}$	$14\frac{1}{2}$	$18\frac{1}{2}$	$18\frac{1}{2}$	$18\frac{1}{2}$
Over spun-yarn when used .	—	—	—	—	$9\frac{3}{4}$

Oakum, Pitch, &c., for Woodwork.

Table showing the Quantity and Description of Oakum, &c., used in Caulking 'New Work' in H.M. Dockyards.

	Thickness of Plank	Double Threads of Oakum	Single Threads of Spun Yarn		Thickness of Plank	Double Threads of Black Oakum	Double Threads of White Oakum
Wales and bottom plank	Ins.			Topsides and waterways	Ins.		
	10	13 in No.	2 in No		9	11 in No.	—
	9	12 „	2 „		8	10 „	—
	8	11 „	2 „		7	9 „	—
	7	10 „	2 „		6	7 „	—
	6	8 „	2 „		5	5 „	1 in No.
	5	6 „	2 „		4	4 „	1 „
	4	5 „	2 „		3	3 „	1 „
	3	4 „	1 „		2½	2 „	1 „
	2½	3 „	—				
	2	2 „	—				
	1	1 „	—				
Gun decks	4	3 „	—		—	—	1 „
	3	2 „	—		—	—	1 „
		Single Threads of Black Oakum	Single Threads of White Oakum				
Weather decks	3	2 in No.	1 in No.				
	2½	2 „	1 „				
	2	1 „	1 „				

Weight of Spun-yarn of different Sizes, in lbs., required to fill every 100 ft. of Seam in Length.

Materials	Number of Yarns					
	12	9	6	4	3	2
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lb.
Spun-yarn . .	5¼	3¾	2½	1¾	1¼	¼

Table of Alloys.

Alloy	Component Parts			
	Copper	Tin	Zinc	Brass
Soft gun-metal	16	1	—	—
Metal for toothed wheels . .	$10\frac{3}{4}$	1	—	—
" " " . .	16	$2\frac{1}{2}$	—	2
Hard bearings for machinery .	8	1	—	—
Gun metal, Admiralty . . .	88	10	2	—
Speculum metal	$2\frac{1}{2}$	1	—	—
Sound copper castings . .	1	—	32	—
Tombac, or red brass . . .	8	—	1	—
Red sheet brass	$5\frac{1}{4}$	—	1	—
Brass that solders well . .	$2\frac{5}{8}$	—	1	—
Ordinary brass	2	—	1	—
Muntz metal	$1\frac{1}{2}$	—	1	—
Extremely tenacious metal . .	16	$1\frac{1}{2}$	$\frac{1}{2}$	—
Bearings to stand great strains .	16	$2\frac{1}{2}$	$\frac{1}{2}$	—
Extremely hard metal . .	16	$2\frac{1}{2}$	$2\frac{1}{2}$	—
Government standard metal .	144	$14\frac{3}{4}$	—	12
Articles for turning . . .	—	2	—	$1\frac{1}{2}$
Bearings, nuts, &c. . . .	—	$2\frac{1}{2}$	—	$1\frac{1}{2}$
Bell metal	16	5	—	—
Statuary bronze	90	2	5	—

Table of Solders.

Solders	Component Parts					Flux
	Copper	Tin	Lead	Zinc	Bismuth	
Coarse solder for plumbers . .	—	1	3	—	—	Resin
Fine solder for plumbers . .	—	1	2	—	—	"
Solder for tin .	—	$1\frac{1}{2}$	1	—	—	" or chloride of zinc
" pewter .	—	3	4	—	2	" "
" bismuth	—	2	2	—	1	" "
Brazing, soft .	4	1	—	3	—	Sal ammoniac or chloride of zinc
" hard .	1	—	—	1	—	
" hardest .	3	—	—	1	—	

Varnishes.

Black Japan for Metals.—Burnt umber 4 ozs., asphaltum $1\frac{1}{2}$ oz., boiled oil 2 quarts. Mix by heat and thin with turpentine.

Another Recipe.—Amber 12 ozs., asphaltum 2 ozs. Fuse by

heat; add boiled oil half a pint, resin 2 ozs.; when cooling add 16 ozs. of oil of turpentine.

Black Japan Varnish.—Bitumen 2 ozs., lamp black 1 oz., Turkey umber ½ oz., acetate of lead ½ oz., Venice turpentine ½ oz., boiled oil 12 ozs. Melt the turpentine and oil together, carefully stirring in the rest of the ingredients, previously powdered. Simmer all together for ten minutes.

Cabinetmaker's Varnish.—Pale shellac 700 parts, mastic 65 parts, strongest alcohol 1,000 parts by measure. Dissolve and dilute with alcohol.

Cabinet Varnish.—Fused copal 14 lbs., hot linseed oil 1 gallon, hot turpentine 3 gallons. Properly boiled, dries very quickly.

Cheap Oak Varnish.—Dissolve 3½ lbs. of pale resin in 1 gallon of oil of turpentine.

Common Varnish.—Dissolve 1 part of shellac in 7 or 8 of alcohol.

Copal Varnish.—Copal 300 parts, drying linseed oil 125 to 250 parts, spirit of turpentine 500 parts. Fuse the copal as quickly as possible; then add the oil, previously heated to nearly boiling point; mix well; then cool a little and add the spirit of turpentine; again mix well, and cover up till it has cooled down to 130° Fahrenheit; then strain.

Copal Varnish for Metals, Chains, &c.—Copal melted and dropped into water 3 ozs., gum sandarach 6 ozs., mastic 2½ ozs., powdered glass 4 ozs., Chio turpentine 2½ ozs., alcohol of 85 per cent. 1 quart. Dissolve by gentle heat.

Gold Varnish.—Turmeric 1 drachm, gamboge 1 drachm, oil of turpentine 2 pints, shellac 5 ozs., sandarach 5 ozs., dragon's blood 7 drachms, thin mastic varnish 8 ozs. Digest with occasional shaking for 14 days in a warm place; then set it aside to fine and pour off the clear.

Mastic Varnish.—Gum mastic 5 lbs., spirits of turpentine 2 gallons. Mix with gentle heat in a close vessel; then add pale turpentine varnish 3 pints.

Table Varnish.—Dammar resin 1 lb., spirits of turpentine 2 lbs., camphor 200 grains. Digest the mixture for 24 hours. The decanted portion is fit for immediate use.

Another Recipe.—Oil of turpentine 1 lb., bee's wax 2 ozs., colophony 1 drachm.

Turpentine Varnish.—Resin 1 part, boiled oil 1 part. Melt and then add turpentine 2 parts.

Varnish for Iron-work.—Dissolve 10 parts of clear grains of mastic, 5 parts of camphor, 15 parts of sandarach, and 5 parts of elemi in a sufficient quantity of alcohol, and apply cold.

Another Recipe.—Dissolve in about 2 lbs. of tar oil ½ lb. of asphaltum, ½ lb. of powdered resin. Mix hot in an iron kettle and apply cold.

Varnish for Metals.—Dissolve 1 part of bruised copal in 2 parts of strongest alcohol. It dries very quickly.

Another Recipe.—Copal 1 part, oil of rosemary 1 part, strongest alcohol 2 or 3 parts. This should be applied hot.

White Copal Varnish.—Copal 16 parts; melt, and add hot linseed oil 8 parts, spirits of turpentine 15 parts. Colour with the finest white lead.

White Priming for Japanning.—Parchment size ⅔, isinglass ⅓.

White Varnish.—Tender copal 7½ ozs., camphor 1 oz., alcohol of 95 per cent. 1 quart; dissolve, then add 2 ozs. of mastic, 1 oz. of Venice turpentine; again dissolve, and strain.

White Spirit Varnish.—Sandarach 25 parts, mastic in tears 6 parts, strongest alcohol 100 parts, elemi 3 parts, Venice turpentine 6 parts. Dissolve in closely corked vessel.

LACQUERS.

To make Lacquer.—Mix the ingredients and let them stand in a warm place for 2 or 3 days, shaking them freely till the gum is dissolved, after which let them settle for 48 hours, when the clear liquor may be poured off ready for use. Pulverised glass is sometimes used to carry off impurities.

Gold Lacquer.—Ground turmeric 1 lb., gamboge 1½ oz., powdered gum sandarach 3½ lbs., shellac ¾ lb., spirits of wine 2 gallons. Shake till dissolved, then strain and add 1 pint of turpentine varnish.

Gold Lacquer for Brass not Dipped.—Alcohol 4 gallons, turmeric 3 lbs., gamboge 3 ozs., gum sandarach 7 lbs., shellac 1½ lb., turpentine varnish 1 pint.

Gold Lacquer for Dipped Brass.—Alcohol 36 ozs., seed-lac 6 ozs., amber 2 ozs., gum gutta 2 ozs., red sandal-wood 24 grains, dragon's blood 60 grains, Oriental saffron 36 grains, pulverised glass 4 ozs.

Good Lacquer.—Alcohol 8 ozs., gamboge 1 oz., shellac 3 ozs., annotto 1 oz., solution of 3 ozs. of seed-lac in 1 pint of alcohol; when dissolved, add Venice turpentine ½ oz., dragon's blood ¼ oz. Keep in a warm place 4 or 5 days.

Good Lacquer for Brass.—Seed-lac 6 ozs., amber or copal 2 ozs., best alcohol 4 gallons, pulverised glass 4 ozs., dragon's blood 40 grains, extract of red sandal-wood obtained by water 30 grains.

Lacquer for Dipped Brass.—Alcohol of 95 per cent. 2 gal-

lons, seed-lac 1 lb., gum copal 1 oz., English saffron 1 oz., annotto 1 oz.

Another Recipe.—Alcohol 12 gallons, seed-lac 9 lbs., turmeric 1 lb. to a gallon of the above mixture, Spanish saffron 4 ozs. The saffron is only to be added for bronze work.

Lacquer Varnish.—Add so much turmeric and annotto to lac varnish as will give the proper colour, and squeeze through a cloth.

Pale Lacquer for Brass.—Alcohol 8 gallons, dragon's blood 4 lbs., Spanish annotto 12 lbs., gum sandarach 13 lbs., turpentine 1 gallon.

Dipping Acids.

Aquafortis Bronze Dip.—Nitric acid 8 ozs., muriatic acid 1 quart, sal ammoniac 2 ozs., alum 1 oz., salt 2 ozs., water 2 gallons. Add the salt after boiling the other ingredients, and use it hot.

Brown Bronze Dip.—Iron scales 1 lb., arsenic 1 oz., muriatic acid 1 lb.; a piece of solid zinc, 1 oz. in weight, to be kept in while using.

Brown Bronze Paint for Copper Vessels.—Tincture of steel 4 ozs., spirits of nitre 4 ozs., essence of dendi 4 ozs., blue vitriol 1 oz., water ½ pint. Mix in a bottle. Apply it with a fine brush, the vessel being full of boiling water. Varnish after the application of the bronze.

Bronze for all kinds of Metals.—Muriate of ammoniac (sal ammoniac) 4 drachms, oxalic acid 1 drachm, vinegar 1 pint. Dissolve the oxalic acid first.

Dipping Acid.—Sulphuric acid 12 lbs., nitric acid 1 pint, nitre 4 lbs., soot 2 handfuls, brimstone 2 ozs. Pulverise the brimstone and soak it in water 1 hour; add the nitric acid last.

Another Recipe.—Sulphuric acid 4 gallons, nitric acid 2 gallons, saturated solution of sulphate of iron (copperas) 1 pint, solution of sulphate of copper 1 quart.

Good Dipping Acid for Cast Brass.—Equal quantities of sulphuric acid, nitre, and water. A little muriatic acid may be added.

Green Bronze Dip.—Wine vinegar 2 quarts, verditer green 2 ozs., sal ammoniac 1 oz., salt 2 ozs., alum ½ oz., French berries 8 ozs. Boil the ingredients together.

Ormolu Dipping Acid for Sheet Brass.—Sulphuric acid 2 gallons, nitric acid 1 pint, muriatic acid 1 pint, water 1 pint, nitre 12 lbs. Put in the muriatic acid last, adding a little at a time, and stir with a stick.

Another Recipe.—Sulphuric acid 1 gallon, sal ammoniac 1 oz.,

flowers of sulphur 1 oz., blue vitriol 1 oz., saturated solution of zinc in nitric acid mixed with equal quantity of sulphuric acid 1 gallon.

Vinegar Bronze for Brass.—Vinegar 10 gallons, blue vitriol 3 lbs., muriatic acid 3 lbs., corrosive sublimate 4 grains, sal ammoniac 2 lbs., alum 8 ozs.

Cements and Glues.

Cement for Earthen and Glass Ware.—Isinglass dissolved in proof spirit and soaked in water 2 ozs. (thick); dissolve in this 10 grains of very pale gum ammoniac (in tears) by rubbing them together, then add 6 large tears of gum mastic dissolved in the least possible quantity of rectified spirit.

Cement for Iron Tubes, &c.—Finely powdered iron 60 parts, sal ammoniac 1 pint, sufficient water to form into a paste.

Cement for Plumbers.—Black resin 1 part, brick dust 2 parts. Melt together.

Cement for Leaky Boilers.—Powdered litharge 2 parts, fine sand 2 parts, slaked lime 1 part.

Cement for Joining Metals and Wood.—Stir calcined plaster into melted resin until reduced to a paste; add boiled oil till brought to the consistency of honey. Apply warm.

Cast-iron Cement.—Clean iron borings or turnings pounded and sifted 50 to 100 parts, sal ammoniac 1 part. When it is to be applied moisten it with water.

Turner's Cement.—Bee's wax 1 oz., resin ½ oz., pitch ½ oz. Melt and stir in fine brick dust.

Coppersmith's Cement.—Powdered quick lime mixed with bullock's blood and applied immediately.

Engineer's Cement.—Equal weights of red and white lead mixed with drying oil. Spread on tow or canvas.

Cement for Joining Metal and Glass.—Copal varnish 15 parts, drying oil 5 parts, turpentine 3 parts, oil of turpentine 2 parts, liquid glue 5 parts. Melt in a bath and add 10 parts of slaked lime.

Gasfitter's Cement.—Resin 4½ parts, wax 1 part, Venetian red 1 part.

Cement for Fastening Blades into Handles.—Shellac 2 parts, prepared chalk 1 part, powdered and mixed.

Cement for Pots and Pans.—Partially melt 2 parts of sulphur and add 1 part of fine blacklead. Mix well. Pour on stone to cool, and then break it in pieces. Use like solder with an iron.

Cement for Cracks in Stoves.—Finely pulverised iron made into a thick paste with water glass.

Very Strong Glue.—Mix a small quantity of powdered chalk with melted common glue.

Glue to Resist Moisture.—Boil 1 lb. of common glue in 2 quarts of skimmed milk.

Marine Glue.—Cut caoutchouc 4 parts into small pieces and dissolve it by heat and agitation in 34 parts of coal naphtha, add to this solution 64 parts of powdered shellac, and heat the whole with constant stirring until combination takes place, then pour while hot on to metal plates to form sheets. When used must be heated to 280° Fahr.

Liquid Glue.—Dissolve 1 part of powdered alum in 120 parts of water; add 120 parts of glue, 10 parts of acetic acid, and 40 parts of alcohol. Digest.

Another Recipe.—Dissolve 2 lbs. of good glue in 2⅛ pints of hot water, add gradually 7 ozs. nitric acid, and mix well.

Parchment Glue.—Parchment shavings 1 lb., water 6 quarts; boil until dissolved, then strain and evaporate slowly until of proper consistency.

Draughtsman's or Mouth Glue.—Glue 5 parts, sugar 2 parts, water 8 parts. Melt in water bath and cast in moulds. For use dissolve in warm water or moisten in the mouth.

WOOD-STAINING.

Mahogany Colour (Dark).—Boil together in a gallon of water ½ lb. of madder and 2 ozs. of logwood. When the wood is dry, after having been washed over with the hot liquid, go over again with a solution of 2 drachms of pearl ash in a quart of water.

Mahogany Colour (Light).—Wash the surface with diluted nitrous acid, and when dry use the following:—dragon's blood 4 ozs., common soda 1 oz., spirits of wine 3 pints. When well dissolved, strain.

Rose Wood.—Boil 8 ozs. of logwood in 3 pints of water until it is reduced to half. Apply boiling hot two or three times. The stain for the streaks is made from a solution of copperas and verdigris in a decoction of logwood.

Ebony.—Wash the wood with a solution of sulphate of iron; when dry, apply a mixture of logwood and nut galls; when dry, wipe with a sponge and polish with linseed oil.

ENAMELS.

White Enamel.—Potash 25 parts, arsenic 14 parts, glass 13 parts, saltpetre 12 parts, flint 5 parts, and litharge 3 parts.

Black Enamel.—Clay 2 parts, protoxide of iron 1 part.

Blue Enamel.—Fine paste 10 parts, nitre 3 parts; colour with cobalt.

Green Enamel.—Frit 1 lb., oxide of copper ½ oz., red oxide of iron 12 grs.

Yellow Enamel.—White lead 2 parts; alum, white oxide of antimony, and sal ammoniac, each 1 part.

TRACING PAPER.

Nut oil 4 parts, turpentine 5 parts; mix and apply to the paper, then rub dry with flour and brush it over with ox gall.

INDIAN INK.

Finest lamp black made into a thick paste with thin isinglass or gum water, and moulded into shape. It may be scented with essence of musk.

COPYING INK.

Add 1 oz. of moist sugar or gum to every pint of common ink.

STAIRCASES OR COMPANION LADDERS.

The ordinary tread of a stair or step is 8 ins., and rise 7½ ins.; above or below that ½ in. rise must be subtracted or added for every inch added to or taken from the width of tread, as the case may be.

CASK-GAUGING.

C = contents of cask in gallons.

D = middle or bung diameter in ins.

L = length in ins.

d = end or head diameter in ins.

$$C = \cdot0009442L(2D^2 + d^2) \text{ considerably curved.}$$

$$C = \cdot0009442L(2D^2 + d^2) - \tfrac{2}{3}(D - d)^2 \text{ moderately curved.}$$

$$C = \cdot0014162L(D^2 + d^2) \text{ very little curve.}$$

$$C = \cdot0000315L(39D^2 + 25d^2 + 26Dd) \text{ any form.}$$

VARIATIONS OF TIDES.

The difference in time between high water and high water averages about 49 minutes.

Galvanising Iron Articles.

1. *Cleaning the Work.*—Any paint or old work should be burnt off before being placed in the acid bath.

2. The acid bath for cleaning the work should consist of water 40 parts, muriatic acid 1 part.

3. Two or three hours in the acid bath will remove dirt and oxide. Cast articles generally require longer time than wrought. Work put in at night may remain without injury till the next morning.

4. When the bath ceases to act fresh acid should be added till it acts as at first. If the acid solution has become thick from the work, it should be allowed to settle, and the clear liquid syphoned off, the bath cleansed, and the liquid again returned.

5. When the work is removed from the acid bath it should be washed in water, and all dirt or oxide removed by brushing or scouring. It should then be placed for two or three minutes in a bath composed of water 6 parts, muriatic acid 1 part. On removal from this bath it should be placed in a clean, warm place to dry.

6. As far as practicable the work should be taken warm from the drying-furnace to the zinc bath. It should be lowered endways slowly into the molten zinc, so as to remove any loose oxide or air from the surface, and allowed to remain long enough to become as hot as the zinc. When it is considered this has been effected it should be raised slowly; if the zinc does not completely cover and flow freely over and from the surface, it must be again lowered and allowed to remain longer. On its final removal some powdered sal-ammoniac should be thrown from the hand on the surface, which greatly helps to make the surface smooth and remove the surplus zinc. When this is done the work should be put aside to cool gradually. It must not be dipped in water when hot, nor chilled in cold air. Articles with joints should be worked whilst cooling, to prevent being set fast.

Zinc Bath.

1. The metal must never be allowed to cool and set fast in the bath.

2. At night the bath should be covered by a sheet of iron, to prevent loss of heat, the fire made up, and again seen to once in the night.

3. When from want of work the operation is to be suspended for a time, the zinc should be ladled out into ingots or cakes. In the case of small baths this is done every night to save attention and fuel in the night.

4. The zinc bottoms which form in the bath should be raked out as soon as they form to the depth of two inches in a large bath or one inch in a small one; and in dipping articles care should be taken not to lower them down far enough to touch the zinc bottoms.

TEMPERING STEEL.

Colour.	Temperature.	Purpose.
Light straw . .	430°–440° . .	turning tools for metals.
Dark " . .	470°–480° . .	tools for wood, screw taps, and dies.
Dark yellow . .	500° }	hatchets, chipping chisels,
Light purple . .	530° }	saws, &c.
Dark " . .	550°	springs, &c.

CONDUCTING POWERS OF VARIOUS SUBSTANCES.

Soft woods are not such good conductors of sound as the harder kinds. The comparison between metals is as follows:—

Gold = 1,000.	Copper = 898.	Zinc = 363.
Silver = 973.	Iron = 374.	Lead = 180.

SIZES FOR LIGHTNING CONDUCTORS.

Copper rod, $\frac{3}{4}$ in. diam.
" pipe $1\frac{1}{8}$ in. diam., $\frac{1}{8}$ in. thick.
Iron rod galvanised, $1\frac{3}{4}$ in. diam.
" pipe, $2\frac{1}{2}$ ins. diam., $\frac{3}{4}$ in. thick.
Flat copper bar, 3 ins. wide by $\frac{1}{8}$ in. thick.

PRESERVATIVE FOR STEEL.

Caoutchouc 1 part, turpentine 16 parts, and boiled oil 8 parts, well mixed and boiled together. The caoutchouc should first be dissolved in the turpentine by a gentle heat, and the boiled oil then added. It should be applied with a brush, and it may be removed by turpentine.

SPECIFIC GRAVITY.

W = weight of body in air. w = weight of body in water.

L = weight of lead and body in water.

l = weight of lead in water.

(1) Bodies heavier than water. (2) Bodies lighter than water.

$$\text{Sp. gr.} = \frac{W}{W - w} \qquad \text{Sp. gr.} = \frac{W}{(W + l) - L}.$$

Note.—In the second example the body is sunk by attaching to it a heavy substance such as lead.

TABLE SHOWING THE NUMBER OF CUBIC FEET REQUIRED TO STOW ONE TON WEIGHT OF VARIOUS SUBSTANCES.

Substances	Cu. Ft. to a Ton	Substances	Cu. Ft to a To
Ashes, pot and pearl	40	Indigo, in cases	66
Ballast, Thames	22	Linseed	56
Barley	47	Marl	28
Bread, in bulk	124	Molasses	60
Coal, Admiralty	48	Oats, in bulk	61
„ Newcastle	45	Rice, in bags	45
„ Welsh	40	Rum, in casks	60
Coffee, in bags	61	Saltpetre	36
Cotton, compressed	50	Sand, pit	22
Earth mould	33	„ river	21
Firewood	288	Sandstone	14
Flax	88	Shingle, clean	24
Flour, in barrels	50	Slate	13
Freestones	16	Sugar, in bags	39
Ginger	80	Tares, in bulk	48
Granite stone	14	Tea, in boxes	111
Gravel, coarse	23	Timber, hard	40
Hay, compressed	105	„ soft	50
„ uncompressed	140	Turmeric	66
Hemp	64	Silk, in bales	128
Hides, well packed	64	„ pieces, in cases	110
„ loosely packed	84	Wheat, in bulk	45

TABLE GIVING THE VARIOUS SUBSTANCES WHICH IN INDIA ARE RECKONED AT 50 CUBIC FEET TO THE TON MEASUREMENT.

Apparel	Elephants' teeth	Roping, in coils
Arrowroot, in cases	Ginger, in bags	Sago, in cases
Bee's wax	Gums, in cases	Sal ammoniac
Blackwood	Gunny bags	Sarsaparilla
Books	Hemp, in bales	Senna, in bales or bags
Borax, in cases	Hides and skins, in bales	Shellac, in cases
Camphor, in cases	Indigo, in cases	Silk piece goods
Cassia, all kinds	Mace, in cases	Skins
Cigars, in boxes	Mother-of-pearl, in cases	Soap, in bars
Cinnamon, in bales	Musk, in cases	Stick lac, in cases
Cloves, in chests	Nutmegs, in cases or casks	Tallow
Coffee, in cases or bags	Nux vomica, in bags	Tea, in chests
Coir fibre, in bales	Raw silk, in bales	Timber, hewn
Colocynth, in cases	Rhubarb, in cases	Tobacco, in bales
Cotton, in bales		Tortoise shells
Cowries, in bags		Wines, in casks
Cummin seed		Wool, in bales

Note.—In England 40 cubic feet is generally taken as a ton measurement (see *Tonnage*, p. 528).

Table of the Weight of Provisions as allowed in the Royal Navy for One Man for Fourteen Days and for 1,000 Men for Four Months.

Kind of Provision	For 1 Man for 14 Days: Net Allowance	For 1 Man for 14 Days: Gross Weight	For 1,000 Men for 4 Months: Net Allowance				Tare of Casks and Packages				Gross Weight			
	Lbs.	Lbs.	T.	Cwt.	Qr.	Lb.	T.	Cwt.	Qr.	Lb.	T.	Cwt.	Qr.	Lb.
Bread .	14	14·25	53	19	3	22	0	19	1	2	54	19	0	24
Spirits . .	4·016	5·0	15	9	3	14	3	16	1	14	19	6	1	0
Salt beef .	5·25	8·78	20	4	3	24	13	12	0	24	33	17	0	20
Salt pork .	5·25	8·48	20	4	3	24	12	8	3	26	32	13	3	22
Flour .	5·25	6·15	20	5	0	9	3	9	0	26	23	14	1	7
Peas . .	3·5	4·125	13	10	0	9	2	8	0	0	15	18	0	9
Oatmeal .	·75	·88	2	17	3	10	0	9	3	1	3	7	2	11
Sugar .	1·31	1·601	5	0	3	23	1	2	1	12	6	3	1	7
Cocoa .	·875	1·105	3	7	1	21	0	17	2	13	4	5	0	6
Tea . .	·218	·295	0	16	3	6	0	6	0	9	1	2	3	15
Vinegar .	1·3	1·59	5	0	0	22	1	2	1	3	6	2	1	25
Tobacco .	—	—	3	11	1	20	1	8	2	8	5	0	0	0
Soap . .	—	—	1	15	2	24	0	7	3	4	2	3	2	0
Total . .	—	—	166	5	1	4	42	8	2	2	208	13	3	6

Table of the Weight of Provisions as allowed in the Royal Navy for each Man per Diem for Fourteen Days.

Days	Bread*	Spirits†	Beef	Pork	Flour	Peas†	Oatmeal†	Sugar	Cocoa	Tea	Vinegar†
	Lbs.	Pts.	Lbs.	Lbs.	Lbs.	Pts.	Pts.	Ozs.	Ozs.	Ozs.	Pts.
Sunday . .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Monday . .	1	¼	—	¾	—	½	—	1½	1	¼	—
Tuesday .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Wednesday .	1	¼	—	¾	—	½	½	1½	1	¼	½
Thursday .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Friday . .	1	¼	—	¾	—	½	—	1½	1	¼	—
Saturday .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Sunday . .	1	¼	—	¾	—	½	—	1½	1	¼	—
Monday . .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Tuesday .	1	¼	—	¾	—	½	—	1½	1	¼	—
Wednesday .	1	¼	¾	—	¾	—	½	1½	1	¼	½
Thursday .	1	¼	—	¾	—	½	—	1½	1	¼	—
Friday . .	1	¼	¾	—	¾	—	—	1½	1	¼	—
Saturday .	1	¼	—	¾	—	½	—	1½	1	¼	—
Total for 14 days	14	5½	5¼	5¼	5¼	3½	1	21	14	3½	1

* Bread takes 6 cu. ft. of stowage for a bag of 112 lbs.=124 cu. ft. per ton.

† One gallon of spirits=9·18 lbs. One gallon of vinegar =10·4 lbs.
„ peas =8·0 „ „ oatmeal =6·0 „

TABLE GIVING THE GOVERNMENT EMIGRATION BOARD'S DIETARY SCALE.

Days	Beef	Pork	Preserved [redacted]	Suet	Butter	Biscuit	Flour	Rice or Oatmeal	Peas	Fresh Potatoes	or Preserved Potatoes	Carrots	Onions	Raisins	Tea	Coffee, Roasted	Sugar, Raw	Molasses (in India)	Water
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Pint	Lbs.	Lb.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Qts.
Sunday . .	—	—	6	2	—	2	20	4	—	1	¼	—	—	4	½	—	4	—	3
Monday .	8	—	—	—	3	2	12	4	—	—	—	4	—	—	—	½	—	4	3
Tuesday .	—	8	—	—	—	2	12	4	¼	—	—	—	—	—	½	—	4	—	3
Wednesday .	—	—	8	2	3	2	12	4	—	1	¼	—	3	—	—	½	—	—	3
Thursday .	—	—	—	—	—	2	12	4	—	—	—	4	—	4	—	—	4	—	3
Friday . .	8	—	6	—	—	2	12	4	¼	1	¼	—	—	—	½	½	—	4	3
Saturday .	—	6	—	2	3	2	12	4	—	—	—	—	—	—	—	½	4	—	3
Weekly totals	16	14	20	6	9	14	92	28	½	3	¾	8	3	8	1½	2	16	8	21

Lime juice 6 ozs. (within tropics), and mixed pickles ½ gill, twice weekly. Mustard ½ oz., pepper ½ oz., salt 2 ozs., once a [redacted].

TABLE GIVING THE WEIGHT OF PROVISIONS, STORES, &c., AS ALLOWED TO H.M.S. 'MONARCH' AND 'DEVASTATION.'

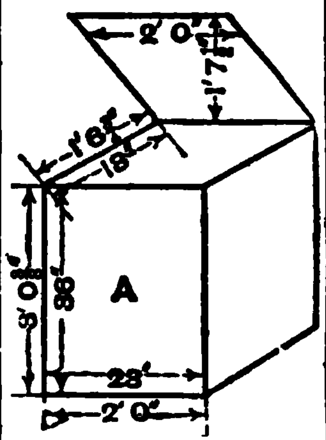
Nature of Stores, &c.	'Monarch'	'Devastation.'	Nature of Stores, &c.	'Monarch'	'Devastation.'
Complement of men and officers	525 No.	250 No.	No. of weeks' consumption for water	4 No.	2 No.
Officers' men and effects . .	65 tons	32 tons	. .	63 tons	10·5 tons
Officers' stores and slops . .	21 "	12 "	. .	12 "	2 "
Water	63 "	15·8 "	1 . .	12 No.	4 No.
Tare of tanks to do. . . .	12 "	3 "	Warrant officers' stores . . .	65 tons	34 tons

Note.—The Admiralty rule is to allow 85 tons of provisions and 170 tons of water, including tanks, for 1,000 men for 4 weeks, and 150 tons for 1,000 men and their effects=3 cwt. per man.

DIMENSIONS OF CASKS, BOXES, &c., IN USE FOR STOWING PROVISIONS IN H.M.'S SERVICE.

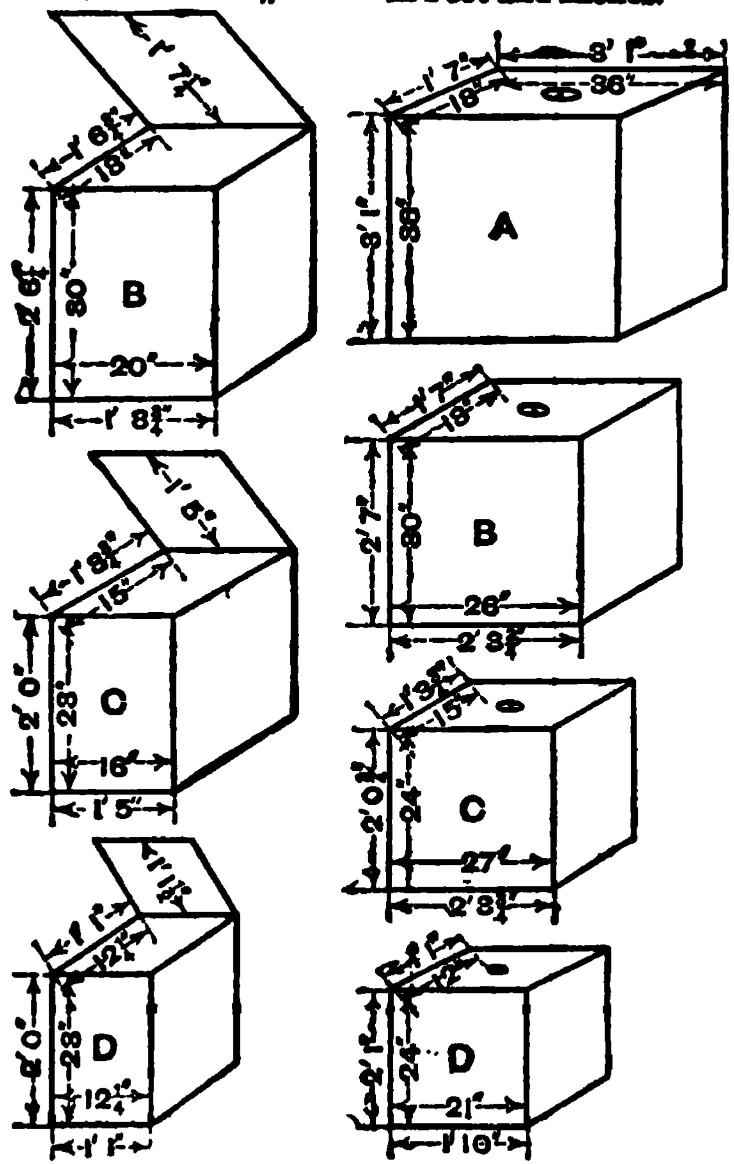
Name of Provision	Net Weight	Gross Weight	Cubical Contents (in feet)	Boxes	Barrels	Half Hogsheads	Cases	Small Casks	Bags
	lb.	lb.	lb.	ft.in. in. in.	ft.in. ft.in.	ft.in. ft.in.	lb. ft.in. ft.in. ft.in.	lb. ft.in. ft.in.	lb. ft.in. ft.in. ft.in.
Biscuit .	50	51	2½	—	—	—	—	—	50} 2 1 × 1 9 × 1 0
	100	102	5	—	—	—	—	—	100} 2 7 × 2 1 × 1 4
Spirits .	HH 26 G	HH 296	HH 8¼	—	—	—	—	—	—
	B 36 G	B 421	B 11¼	—	2 8½×2 1 diam.	2 4½×1 11 diam.	—	—	—
Sugar .	HH 280	HH 339	HH 8¼	—	—	—	—	—	—
	B 390	B 460	B 11¼	—	2 8½×2 1 „	2 4½×1 11 „	—	—	—
Chocolate	100	119	100} 2¼	—	—	—	100} 1 8¾×1 1¼×1 1¼	—	—
	50	64	50} 1½	—	—	—	50} 1 2 ×1 1¼× 10¾	—	—
Soluble do.	50	64	50 1½	—	—	—	50 1 1 × 11¼×1 3	—	—
Tea . .	100	126	100} 5	—	—	—	100} 2 0 ×1 6 ×1 5½	—	—
	60	76	68} 3	—	—	—	60} 1 8½×1 6 ×1 3	—	—
	Small casks								
Salt Pork .	100	SC 202	—	—	—	—	—	—	—
	HH 200	HH 360	HH 9	—	—	—	—	—	—
	B 300	B 530	B 12½	—	2 7½×2 4 „	2 4 ×1 9 „	—	100 2 1½×1 6½ diam.	—
Peas . .	HH 280	HH 269	HH 8¼	—	—	—	—	—	—
	B 320	B 374	B 11¼	—	2 6½×2 1 „	2 3 ×1 11 „	—	—	—
	HH 200	HH 360	Foreign barrel 9	—	Foreign barrel	—	—	—	—
Salt Beef .	B 300	B 530	HH 9	—	2 8½×2 1 diam.	—	—	—	—
	SC 100	SC 202	B 11½	—	2 6½×2 1 „	2 5½×1 10½ „	—	—	—
Suet . .	80	181	80} 5½	—	—	—	—	—	—
	50	—	50} 3	—	—	—	—	—	—
	30	—	30} 2	—	—	—	—	—	—
Raisins .	Case 112	156	C 3¼	—	—	—	—	—	—
	Box 55	67	B 1½	1 8¾×10×9¾	—	—	—	—	—
Oatmeal .	HH 250	HH 289	—	—	—	—	2 0×1 10½× 11½	—	—
	B 330	B 384	HH 8¼	—	—	2 3 ×1 11 „	—	—	—
Mustard .	50	78	50} 3	—	—	—	50} 2 2¼×1 4 × 8½	—	—
	100	138	100} 2	—	—	—	100} 3 0¼×1 4 × 11¼	—	—
Pepper .	50	78	50} 3	—	—	—	50} 2 2¼×1 4 × 8½	—	—
	100	138	100} 2	—	—	—	100} 3 0¼×1 4 × 11¼	—	—
	HH 26 G	HH 317	HH 8¼	—	—	—	—	—	—
	B 36 G	B 450	B 11¼	—	2 8½×2 1 „	2 4½×1 11 „	—	—	—
	Case No. 1 40	95	—	—	—	—	—	—	—
	72	179	—	—	—	—	—	—	—
	36	96	No. 1 C 8¼	—	—	—	—	—	—

DIMENSIONS AND CONTENTS OF TANKS, IRON (PAINT).*

Tanks		Cubic Feet in Tanks	Contents in Gallons	White Lead	Black	Yellow	Red Lead	Litharge	Venetian Red	Queen's Green	Zinc White	Oxide of Iron	Putty	Tallow	Soft Soap and Disinfecting Powder	Portland Cement
Weight of a Cubic Foot of				Lbs. 292	Lbs. 100	Lbs. 113	Lbs. 234	Lbs. 169	Lbs. 115	Lbs. 124·64	Lbs. 115	Lbs. 144	Lbs. 136	Lbs. 59	Lbs. 64	Lbs. 96
Inside Measurements in Inches. Outside do. in Feet and Inches. 	A	8·622	53·887	25·18	862	974	2018	1457	991	1074	991	1241	1172	508	551	827
	B	6·247	39·00	1825	625	706	1462	1055	718	778	718	899	849	368	399	599
	C	3·192	19·96	932	319	360	746	539	367	397	367	459	434	118	204	306
	D	1·916	11·975	559	191	216	448	323	220	238	220	276	260	113	62	184

DIMENSIONS AND CONTENTS OF TANKS, IRON (OIL).

Inside Measurements in Inches.
Outside „ in Feet and Inches.



	Cubic Feet in Tanks	Contents in Gallons	Whiting	Linseed Oil	Turpentine	Mineral Cement	Lime
Weight of a Cubic Foot of	—	—	Lbs. 125	Lbs. 56 or $6\frac{1}{4}$ gals.	Lbs. 50 or $6\frac{1}{4}$ gals.	Lbs. 126	Lbs. 150
				Lbs.			
A . .	13·5	84·375	$1687\frac{1}{2}$	756	675	170	2025
B . .	8·222	51·387	$1027\frac{1}{2}$	$460\frac{1}{2}$	411	$103\frac{1}{2}$	$1233\frac{1}{4}$
C . .	5·625	35·156	$7031\frac{1}{4}$	$314\frac{1}{2}$	281	$70\frac{3}{4}$	$843\frac{3}{4}$
D . .	3·5	21·875	$437\frac{1}{2}$	196	175	44	525

A little oil should always be kept on patent driers.

TABLE GIVING THE WEIGHT OF SHIPS' BOATS AS USED IN HER MAJESTY'S NAVY.

Boats	Lgth.	Breadth	Depth	Weight of each Fitted	Weight of each Unfitted
	ft.	ft. ins.	ft. ins.	cwt. qrs. lbs.	cwt. qrs. lbs
Launch not sheathed	42	11 0	3 9	89 2 0	74 3 0
" "	40	10 6	3 9	82 3 14	67 1 14
Pinnace	32	8 9	3 2	48 2 14	43 1 21
"	30	8 7	3 1	45 3 14	40 3 21
"	28	8 4	2 10	43 2 21	38 2 14
"	26	8 1½	2 8	36 1 8	34 0 12
Cutter	34	—	—	26 0 0	—
"	32	—	—	22 3 14	—
"	30	8 1	2 8½	17 3 14	16 0 7
"	28	7 10½	2 8	15 3 10	14 1 14
"	26	7 5	2 7	12 2 6	11 1 0
"	25	7 3	2 6½	12 1 0	11 0 0
"	23	6 11	2 5½	10 1 21	9 3 0
Cutter or Jolly boat	18	6 0	2 2	7 2 14	7 0 0
Jolly boat	16	5 7	2 2	4 3 21	4 1 14
Gig	32	5 6	2 2	9 3 14	—
"	30	5 6	2 2	9 0 7	8 2 14
"	28	5 6	2 2	8 0 10	7 2 7
"	26	5 6	2 2	7 0 14	6 2 14
"	24	5 6	2 2	6 2 21	6 0 7
"	22	5 6	2 2	5 3 21	5 1 0
"	20	5 6	2 2	6 0 14	5 2 14
Cutter gig	20	6 6	2 6	7 0 0	—
Dingy	14	5 2	2 1	4 0 7	3 2 7
"	12	5 0	2 0	3 0 7	2 3 0
Whale boat	27	5 3	2 6	8 2 0	—
" "	25	5 3	2 4	7 3 0	—
Troop boat	38	—	—	26 3 0	—
Life boat ('White's')	32	—	—	10 1 19	—
" " "	26	—	—	7 3 11	—

TABLE GIVING THE SCANTLINGS OF SHIPS' BOATS AS BUILT IN HER MAJESTY'S NAVY.

	ft. ins.	ft. ins.	ft. ins	ft. ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins
Length	34 0	32 0	30 0	25 0	23 0	20 0	18 0	16 0
Breadth	8 10	8 6	8 1	7 3	6 11	6 4	6 0	5 7
Depth	2 11	2 10	2 8½	2 6¾	2 5½	2 3	2 2	2 1
Keel sided	0 3¼	0 3	0 3	0 2¾	0 2¾	0 2½	0 2¼	0 2¼
Keel moulded	0 5	0 4¾	0 4¾	0 4½	0 4½	0 4¼	0 4	0 4
Stem and Post sided	0 3	0 2¾	0 2¾	0 2½	0 2½	0 2¼	0 2⅛	0 2⅛
Floors sided	0 1¾	0 1½	0 1½	0 1⅜	0 1⅜	0 1¼	0 1	0 1
Floors moulded	0 1½	0 1⅜	0 1⅜	0 1¼	0 1¼	0 1	0 0⅞	0 0⅞
Floors number	22	21	20	17	16	14	13	12
Futtocks sided	0 1½	0 1⅜	0 1⅜	0 1¼	0 1¼	0 1	0 0⅞	0 0⅞
Futtocks moulded	0 1⅛	0 1	0 1	0 0⅞	0 0⅞	0 0¾	0 0⅝	0 0⅝
Futtocks number	68	64	60	50	46	40	36	32
Gunwales deep	0 2⅛	0 2	0 2	0 1⅞	0 1⅞	0 1¾	0 1⅝	0 1⅝
Gunwales thick	0 2¼	0 2⅛	0 2⅛	0 2	0 2	0 1⅞	0 1¾	0 1¾
Number of knees	20	20	20	18	16	16	14	12
Number of breast hooks	2	2	2	2	2	2	2	2
Extra fixed thwarts fo'd	—	—	—	—	1	—	1	—
" No. double-kneed	4	4	4	3	3	3	2	2
" loose	3	3	2	2	1	1	1	1
Mast thwarts, oak, thick	0 1¾	0 1¾	0 1¾	0 1½	0 1½	0 1½	0 1½	0 1½
Mast thwarts, oak, broad	0 9	0 9	0 9	0 9	0 9	0 8½	0 8	0 8
Other thwarts thick	0 1½	0 1½	0 1½	0 1½	0 1½	0 1½	0 1½	0 1½
Other thwarts broad	0 7	0 7	0 7	0 7	0 7	0 7	0 7	0 7
Blank of bottom thick	0 0½	0 0½	0 0½	0 0 7/16	0 0 7/16	0 0 7/16	0 0 7/16	0 0 7/16

Weight of Men and Animals.

A crowd of people closely packed = 85 lbs. per sup. ft.

The average weight of a man = 140 lbs. 6 ozs., or about 15 men to a ton.

A strong cart-horse = 14 cwt. and a cavalry horse = 11 cwt.

An ox = 7 to 8 cwt. and cow = $6\frac{1}{2}$ to 8 cwt.

A pig = 1 to $1\frac{1}{2}$ cwt. and a sheep = $\frac{3}{4}$ to $1\frac{1}{4}$ cwt.

Space Allotted to Animals.

A horse = 120 sup. ft.	A bullock = 40 to 60 sup. ft.
A cow = 90 to 100 sup. ft.	Sheep and pigs = 10 „ 12 „

Ventilation, &c.

Each person should be allowed at least from $2\frac{1}{2}$ to $4\frac{1}{2}$ cu. ft. of fresh air per minute.

The following are average velocities of air in feet per minute in different positions:—

At outlets where foul air escapes from cabins = 150 to 198.
At inlets where fresh air enters cabins = 78 to 96.
In tubes, trunks, chimneys, &c., for fresh or foul air = 720; or—
V = velocity in feet per minute in chimneys, &c.
H = height of shaft, trunk, &c., in feet.
T = mean temperature in trunk in degs. Fahr.
t = temperature of external air in degs. Fahr.
k = coefficient of dilatation of air for 1° Fahr. = ·002

$$V = 8{\cdot}025\sqrt{Hk(T-t)}$$

Inclination of Ships' Sliding Ways.

For small vessels = 1 in 12 to 1 in 14.
For average „ = 1 „ 16 „ 1 „ 18.
For largest „ = 1 „ 20 „ 1 „ 24.

Test Loads of Anchors and Chain Cables.

To find the test load for a given chain cable in tons.

Rule.—Square the diameter of the bolt of the cable in ins., and multiply the result by 18.

To find the diameter of a cable in ins. to suit a given test load.

Rule.—Divide the test load in tons by 18, and subtract the square root of the quotient.

To find the working load of chain rigging.

Rule.—Square the diameter of the bolt in ins., and multiply the result by 8.

To determine the diameter of bolt for a chain cable in ins.

Rule.—Extract the cube root of the load displacement in tons, and multiply the result by ·125.

TABLE GIVING THE NUMBER AND SIZES OF CABLES AND ANCHORS AS SUPPLIED TO SOME OF H.M. ARMOURED STEAM-SHIPS.

NAME OF SHIP	Displacement in Tons	Number and Sizes of Cables								Number and Weights of Anchors							
		Hempen				Iron				Bower		Stream		Kedge		Stern	
		Bower		Stream		Bower		Stream									
		No.	Circumf.	No.	Circumf.	No.	Diameter	No.	Diameter	No.	Weight of One	No.	Weight of One	No.	Weight of One	No.	Weight of One
			ins.		ins.		ins.		ins.		cwt. qr. lb.		cwt. qr. lb.		cwt. qr. lb.		cw. q. lb.
'Minotaur' class	10,627	1	19	1	18	6	2⅜	1	1½	4	112 0 9	1	34 2 16	2	14 1 23	1	45 3 4
'Warrior' "	9,137	1	18½	1	15½	6	2⅜	2	1⅝	4	109 1 32	1	32 0 18	2	22 2 16	2	50 1 4
'Achilles' . .	9,694	1	19	1	13	6	2⅜	1	1½	4	111 0 0	1	25 0 0	2 {1 1	14 0 0 8 0 0	2	40 0 0
'Hercules' . .	8,677	1	—	1	15	5	2⅜	2 {1 1	1⅝ 1½	4	121 0 14	1	41 3 0	2	15 1 14	1	56 1 0
'Bellerophon' .	7,551	1	19	1	15½	5	2⅜	1	1½	4	90 0 16	1	41 3 7	2	11 2 22	—	—
'Royal Alfred' .	6,707	1	18½	1	14	5	2¼	2	1⅞	4	115 1 7	1	24 3 18	2	27 0 2	—	—
'Audacious' .	6,034	1	17½	1	14½	5	2½	1	1½	4 {3A 1M	90 0 7 90 0 7	1A	30 0 0	2A	14 2 14	—	—
'Rupert' . .	5,444	1	17	1	13	4	2⅛	2 {1 1	1¼ 1¾	4M	80 1 17	1M	12 1 17	2A	8 3 25	—	—
'Hotspur' .	4,010	1	16½	1	13½	4	2	1	1¼	4	60 1 15	1	20 1 23	1	9 2 0	—	—
'Pallas' . .	3,787	1	15	1	12	4	2	1	1¼	4	70 2 13	1	21 2 15	2	7 0 21	—	—
'Scorpion' . .	2,751	—	—	—	—	3	1¾	1	1	3	39 1 0	1	11 0 0	2 {1 1	3 0 0 5 0 0	—	—
'Research' . .	1,741	—	—	—	—	3	1⅝	1	1	3A	47 0 0	1A	12 0 10	2	11 1 14	—	—

A = Admiralty. M = Martin.

TABLE GIVING THE NUMBER AND SIZES OF CABLES AND ANCHORS AS SUPPLIED TO SOME OF H.M. UNARMOURED STEAM-SHIPS.

Name of Ship	Displacement in Tons	Cables: Hempen Bower No.	Hempen Bower Circumf.	Hempen Stream No.	Hempen Stream Circumf.	Iron Bower No.	Iron Bower Diameter	Iron Stream No.	Iron Stream Diameter	Anchors: Bower No.	Bower Weight of One	Stream No.	Stream Weight of One	Kedge No.	Kedge Weight of One	Stern No.	Stern Weight of One
			ins.		ins.		ins.		ins.		cwt. qr. lb.		cwt. qr. lb.		cwt. qr. lb.		
'Duncan'	5,724	1	18½	1	14½	5	2¼	1	1⅜	4	90 0 0	1	25 0 0	2	15 0 8	—	—
'Inconstant'	5,782	1	17½	1	14½	5	2¼	1	1¼	4*	108 1 0	1	29 0 0	2	13 0 0	—	—
'Undaunted'	4,020	1	18	1	13½	5	2⅛	1	1¼	4	75 1 0	1	22 0 0	2	6 2 0	—	—
'Rover'	3,494	—	—	1	13½	4	2	1	1¼	4 {3A 1M	31 3 0 30 3 0	1A	19 2 14	2A	6 2 0	—	—
'Encounter'	1,934	1	14½	1	11	4½	1¾	1	1⅛	4	46 1 16	1	12 0 21	2 {1 1	6 2 7 4 2 14	—	—
'Wild Swan'	—	1	—	—	—	3	—	1	—	3	—	1	—	2	—	—	—
'Nassau'	877	—	—	—	—	3	1¼	1	⅞	3	27 1 16	1	17 0 8	2	7 2 20	—	—
'Torch'	570	—	—	—	—	3	1⅛	1	⅞	3	14 0 0	1	6 0 0	1	3 0 0	—	—
'Ariel'	436	—	—	—	—	3	1	1	¾	3	11 1 2	1	6 0 8	1	2 1 27	—	—
'Britomart'	330	—	—	—	—	3	2	1	⅞	2 {1 1	9 1 13 8 2 9	1	5 1 0	1	2 3 20	—	—
'Comet'	254	—	—	—	—	2	⅞	—	—	2	6 2 14	—	—	—	—	—	—

A = Admiralty. M = Martin. * With stock.

Admiralty Transport Regulations.

Families of Non-commissioned Officers—Class I.

(1) A sleeping-place is to be fitted in the most convenient part of the ship. Size according to numbers. The berths are to be in two tiers 6 feet long and 2 feet wide in the clear, and must be at least 3 feet between the rows. Four japanned clothes pegs are to be provided for each person. A separate w.c. is to be provided and placed where most convenient. When more than four families are fitted for, a bath and washing-trough fitted with water supply and waste pipes is to be provided adjoining their quarters, and arranged so that they can pass to it from their sleeping-place. A suitable part of the upper deck is to be marked off for their use. They will mess with the non-commissioned officers Class I. at tables near their sleeping-place.

Women and Children.

(2) Quarters, in the most convenient part of the ship, are to be bulk-headed off, and, when possible, the space should include a hatchway that will give them access to the upper deck. Bed-places may be in two tiers. Each berth to be 6 feet long and 2 feet wide for one adult or two children under ten years old. When convenient there can be two rows in each tier. The lower berths must be 15 inches clear of the deck, and there must be a clear 3 feet between rows of berths.

A seat 9 inches broad is to run round the lower berths 18 inches off the deck.

Iron japanned clothes pegs to be put in where most convenient, 3 for each adult.

A space clear of the berths is to be fitted with washstands, one for each 6 or less number.

Wash-place for women, when possible, should adjoin their quarters. Size not to be less than 6 feet long and 5 feet wide. A bath and washing-troughs to be fitted, the bath 2 feet wide and 18 inches deep. The troughs 20 inches by 12 inches by 10 inches in the clear.

When more than 30 women are fitted for, the size is to be increased, and two baths fitted.

Latrines to be built, when possible, either adjoining their quarters or on the part of the deck nearest to the ladder, leading up from their quarters.

Non-commissioned Officers—Class I.

(3) Will sleep in hammocks, and the mess tables nearest to the sleeping-place of their families will be allotted for their use.

A separate latrine is to be provided for them.

Men, including Sergeants.

(4) To be berthed in hammocks hung from hooks 16 inches apart for the men, and 20 inches for sergeants, each berth to be 9 feet in length, looking in 18 inches at each end.

(5) *Mess tables* fixed to the ship's side length as ordered. 6 feet for 8 men, 7 feet 6 inches for 10 men, 9 feet for 12 men, and so on, 18 inches for every two additional men; to be 2 feet 3 inches wide, made of $1\frac{1}{4}$ inch deal.

(6) *Benches* to ditto, fixed—to be the length of the table and 9 inches wide.

(7) '*Orderly room.*'—If there is a cabin available it will be fitted up as an office, with desks, shelves, stools, &c.

(8) *Valise battens or racks.*—Valises are, when possible, to be stowed overhead over the messes.

(9) *Accoutrement hooks.*—Two stout japanned iron pegs, 6 inches long, are to be provided for each person, and screwed into the battens against ship's side abreast each mess.

(10) *Sea kit racks.*—One for every six messes is to be put up where most convenient for the sea kit bags to be stowed in.

(11) *Latrines and urinals for men* (two seats to be provided for each 100 men fitted for) to be built out on the deck 6 feet high and 5 feet 6 inches wide, both in the clear. The holes of the seats to be oval-shaped $9\frac{1}{2} \times 11$ inches, and 22 inches from centre to centre.

(12) *Wash-place for troops.*—Five troughs and basins to be provided for each 200 men fitted for. Troughs are to be 21 × 16 × 12 inches in the clear. Each top is to have a circular hole in it to receive a 12-inch basin.

Hospitals.

(13) *Standing bed-places*, 3 to every 100 men fitted for, to be built up in one or two tiers, as directed, well clear of the deck and side, 6 feet long and 2 feet 3 inches wide in the clear.

(14) *A hospital* is to be provided for women, when 10 or upwards are carried.

(15) *A dispensary*, 6 feet square, is to be built on the aft side of hospital bulkhead.

Hatchways.

(16) *Booby hatches.*—Each hatchway with ladderway to troop deck must have a booby hatch fitted over it, made so as to afford the greatest amount of light and air to the between decks, and ventilated with one or more large cowls.

Ventilation.

(17) Each deck is to be separately ventilated. In addition to any special system of ventilation that may be ordered.

Lazarette Deck.

(18) *Issuing room* to be never less than 6 feet square.

(19) *Bread room*, to be built against the issuing room, the inside to be fitted to hold one day's allowance.

(20) *Magazine* must be placed under two decks.

(21) *Baggage room*, to be built large enough to take all the regulation baggage, about 800 cubic feet space for each 100 men.

(22) *Blanket room, bedding room, mess utensil room, and parcel room*, to be built the same way as the baggage room, sizes as ordered.

(23) *Helmet room*, to be built in each compartment on the troop deck, of sufficient size for the troops accommodated there.

Prisons—For five men each.

[Two required in vessels carrying 700 men and upwards, one in other vessels.]

(24) *Prison* to be 8 feet wide and 9 feet long both in the clear.

Troop Galley and Bakehouse.

(25) Must be above troop deck. The size required, when galley and bakehouse are together, is 30 superficial feet for the first 100 men, and 15 feet for each additional 100, but when they are separate they each require 20 feet for the 100 men and 10 feet for each additional 100.

Horse Accommodation.

(26) *Stalls* are to be provided for 5 per cent. more horses than the numbers to be embarked, and 5 per cent. of the stalls are to be 6 inches longer and 2 inches wider than the others.

(27) There must be a 2 feet passage between the ship's side and the cant at the rear of the stalls.

(28) *Loose boxes.*—One to be provided amidships on each deck or compartment on which horses are carried.

Dimensions of the Stall.

		ft.	in.
(29) Length from breast to haunch in the clear		6	0
Breadth between parting bars in the clear		2	2
Height of parting bar from platform to top		3	9
" breast rail " " "		3	9
" haunch rail " " "		3	6
Boards fitted as kicking boards (one pair for every 10 stalls)	length	6	9
	breadth	1	6
	thick	0	1½

Saddle and Harness Room.

(30) A space 12 feet square is required for each 100 mounted men.

Crew to be carried.

(31) 30 men for 1,000 tons net register, and $1\frac{1}{2}$ men for each additional hundred tons or part of a hundred tons. These numbers to include master, mates, and all hands.

Under 1,000 tons, complement will be fixed before acceptance.

Height of Freeboard.

(32) All ships conveying troops are required to have a clear side out of water when loaded of $3\frac{1}{2}$ inches for each foot of registered depth of hold, measured from the upper side of the deck plank next the waterway amidships to the water, or if a spar-decked ship, of half the above clear side, measured in like manner, but in no case less than 4 feet 6 inches. If measured in fresh water $\frac{1}{4}$ inch may be abated for each foot of registered depth of hold.

Dead Weight.

(33) The maximum quantity of cargo weighing more than 20 cwt. to 40 cubic feet measurement allowed to be shipped in vessels carrying troops, 15 cwt. to each ton of net registered tonnage.

Height between Decks.

(34) As a rule, troops or horses will only be berthed on decks well provided with ports, or other approved side lights, and having a clear height from top of deck planking to underside of beams of 6 feet 6 inches for men and 7 feet for horses, but under no circumstances will men or horses be carried where there is a less height, measured as above, than 6 feet for men and 6 feet 6 inches for horses.

Officers' Cabins.

(35) Cabins for first and second class adult passengers must NOT BE LESS than 6 feet in height from deck to beam, and must have the following superficial space.

30 superficial	feet	for a	cabin to	hold	one
42	"	"	"	"	two
62	"	"	"	"	three
74	"	"	"	"	four

Bed-places must be at least 6 feet long by 2 feet wide, both in the clear.

The commanding officer, whatever his rank, will have a cabin of not less size than 42 superficial feet.

Berthing and Messing.

(36) Space is usually provided on troop-decks sufficient to berth and mess all the men to be embarked. All sergeants, whatever may be their rank, sleep in hammocks. They have a bed and pillow, in addition to a hammock and two blankets. Non-commissioned officers Class I. mess with their families, and their hammocks will be hung near their messes.

Dimensions of Baggage.

(37) Generally all baggage is to be carried in rectangular boxes.

Cabin Baggage and Baggage of Soldiers' Wives.

(38) Each officer or lady will be allowed two articles of baggage in the cabin. They are to be of the same size and shape as Regulation Box No. 3.

Each soldier's wife may have one box (not higher than 14 inches) in the women's quarters.

Bending Moments and Sizes of Paddle and Spring Beams.

W = load in tons. D = diameter of shaft in ins.
L = length of outboard part of shaft in ins.
L′ = length of projecting part of paddle beam in ins.
M = approximate bending moment of paddle beam.
M′ = approximate bending moment of spring beam at middle.
E = effective sectional area of iron paddle-beam in sq. ins.
B = depth of iron paddle beam in ins.
B′ = depth of square wood in paddle beam in ins.
S = span from centre to centre of paddle beams in ins.

$$W = \frac{D^2 \times L}{4000} \qquad M = W \times L' \qquad M' = \frac{W \times S}{2}$$

$$E = \frac{3M}{4B} \qquad B' = \sqrt[3]{12 \times M}$$

Note.—The breadth of the spring beam should not be less than $\frac{2}{3}$ of the depth of the paddle beams.

Nominal Horse-power.

(*Low-pressure Engines.*)

V = assumed velocity of piston = 128 feet per minute × cube root of length of stroke.
V′ = real velocity of piston in feet per minute.
D = diameter of piston in ins.
N = nominal horse-power for Admiralty *paddle* engines, and for *paddle* and *screw* engines in the merchant service.
N′ = nominal horse-power for Admiralty screw engines.
P = assumed mean effective pressure = 7 lbs. per sq. in.
A = area of piston in sq. ins. L = length of stroke in feet.

$$N = \frac{PVA}{33000} = \frac{D^2\sqrt[3]{L}\dagger}{60} = \frac{D^2\sqrt[3]{L}*}{20} \text{ nearly}$$

$$N' = \frac{PV'A}{33000} = \frac{V'D^2}{6000}$$

Note.—To adopt the above formulæ for high-pressure engines the effective pressure is taken at 21 lbs. per sq. in.

Indicated Horse-power.

A = area of piston in sq. ins. L = length of stroke in feet.
P = mean effective pressure of steam in cylinder in lbs. per sq. in.
R = number of revolutions per minute for single acting.
r = number of revolutions per second.

$$\text{Indicated horse-power} = \frac{L \times A \times P \times R}{33000} = \frac{L \times A \times P \times r}{550}$$

* Non-condensing engines. † Condensing engines.

Quantity Chain Cable for H.M. Ships.

Ins.	Ins.		
From $2\frac{3}{8}$	to 2	Bower	575 fms.
,, $1\frac{7}{8}$	,, $1\frac{3}{4}$	,,	450 ,,
,, $1\frac{5}{8}$	,, $1\frac{1}{2}$	,,	425 ,,
,, $1\frac{3}{8}$	,, $1\frac{1}{4}$	,,	$412\frac{1}{2}$,,
,, $1\frac{3}{8}$	,, $1\frac{1}{8}$	,,	300 ,,
	1	,,	250 ,,
	$\frac{7}{8}$	,,	200 ,,

Kedge Cwt. Cwt.	Ins.		Fms.		Stream 30 cwt. anchor	Fms.	Cwt.	
15 and 9	$2\frac{3}{8}$	Bower	575	$=1\frac{1}{2}$	30 cwt. anchor	100	100	Anchor bower
15 ,, 8	$2\frac{1}{4}$	,,	575	$=1\frac{3}{8}$	25 ,, ,,	,,	95	,, ,,
9 ,, 5	$2\frac{1}{8}$	,,	575	$=1\frac{1}{4}$	20 ,, ,,	,,	75	,, ,,
9 ,, 5	2	,,	575	$=1\frac{1}{4}$	20 ,, ,,	,,	70	,, ,,
8 ,, 4	$1\frac{7}{8}$	,,	450	$=1\frac{1}{4}$	18 ,, ,,	,,	60	,, ,,
6 ,, 4	$1\frac{3}{4}$	,,	450	$=1\frac{1}{8}$	12 ,, ,,	,,	45	,, ,,
5 ,, 3	$1\frac{5}{8}$	,,	425	$=1$	10 ,, ,,	,,	40	,, ,,
5 ,, 3	$1\frac{1}{2}$	,,	425	$=1$	9 ,, ,,	,,	30	,, ,,
5 ,, 3	$1\frac{3}{8}$	,,	$412\frac{1}{2}$	$=\frac{7}{8}$	7 ,, ,,	,,	25	,, ,,
4 ,, 2	$1\frac{1}{4}$	,,	300	$=\frac{7}{8}$	6 ,, ,,	,,	20	,, ,,
3	$1\frac{1}{8}$	,,	300	$=\frac{7}{8}$	6 ,, ,,	,,	14	,, ,,
2	1	,,	250	$=\frac{3}{4}$	5 ,, ,,	,,	9	,, ,,
2	$\frac{7}{8}$	,,	200	$=\frac{3}{4}$	3 ,, ,,	,,	7	,, ,,

Rules for Sizes of Steam Cylinders.

To calculate the diameter of the cylinder.

Let d and D be the diameters of the high and low pressure cylinders respectively; F = allowance of circular inches per NHP, and R = ratio of cylinder capacity; then, $\text{NHP} = \frac{d^2 + D^2}{F}$,

$$d = \sqrt{\frac{\text{NHP} \times F}{1 + R}}, \quad D = \sqrt{\frac{\text{NHP} \times F \times R}{1 + R}}.$$

NHP	Standard Stroke	Stroke in Common Practice	NHP	Standard Stroke	Stroke in Common Practice
	Ins.	Ins. Ins.		Ins.	Ins. Ins.
20	15	15 to 18	140	36	36 to 42
30	18	18 ,, 21	160	36	36 ,, 42
40	21	21 ,, 24	180	39	39 ,, 45
50	24	24 ,, 30	200	39	39 ,, 48
60	27	24 ,, 30	250	42	42 ,, 54
80	30	30 ,, 33	300	45	45 ,, 54
100	33	30 ,, 36	400	48	48 ,, 60
120	33	33 ,, 42	500	48	48 ,, 66

If IHP is used, let n = number of cylinders, R = number of revolutions per minute, S = stroke in feet, P, p mean pressures in high and low pressure cylinders.

$$\text{Diameter of h.p. cylinder} = \sqrt{\frac{\text{IHP} \times 21000}{n \times P \times S \times R}}.$$

$$\text{,,} \quad \text{l.p.} \quad \text{,,} \quad = \sqrt{\frac{\text{IHP} \times 21000}{n \times p \times S \times R}}.$$

Main Steam Pipe.—The mean velocity of steam should not exceed 8,100 feet per minute.

Let S = mean speed of piston in feet per minute.

D = diameter of cylinder.

Diameter of steam pipe

$$= \sqrt{\frac{D^2 \times S}{8100}} = \frac{D}{90} \times \sqrt{S}.$$

To calculate Indicator Diagrams.

A B represents to a certain scale the stroke of the engine, and ordinates at any point represent the mean pressure acting on the piston at that point; the ordinate to the upper part of the curve showing the pressure during the forward stroke, and to the lower part the pressure during the back stroke, so that the area of the curve represents the total pressure acting on the piston during one stroke.

Divide AB into 10 equal parts, and bisect each of these parts, as shown in figure. Draw ordinates through each of these bisecting points, and take the length of the parts (intercepted by the curve) a, b, c, &c., in inches; then mean length of ordinate

$$=\left(\frac{a+b+c+\ .\ .\ .\ +k+l}{10}\right);$$

and if x = force required to compress the spring of indicator 1 inch,

$\therefore$ mean pressure on piston

$$=\frac{(a+b+c+\ .\ .\ .\ +k+l)\times x}{10}=\text{P}.$$

Let S = length of stroke in feet, and n the number of strokes per minute; then, if the engine is double-acting, the work done per minute is

$$=\text{S}\times\text{P}\times n\times 2,$$

and
$$\text{IHP}=\frac{\text{S}\times\text{P}\times n\times 2}{33000}.$$

It is advisable with double-acting engines to take a diagram on both sides of the piston at the same time, and so obtain the mean pressure. With compound engines the horse-power due to each cylinder is found separately, and the results added together to get the total horse-power.

Hyperbolic Expansion of Steam.—If the steam in a cylinder be considered a perfect gas, it will follow Boyle's law in expansion, provided the temperature remains constant. In actual practice these conditions are approximately fulfilled, and in consequence the pressure of the steam at any instant is inversely proportional to its volume. If a diagram similar to an indicator diagram be made for this theoretical case, the curve of pressures will be a rectangular hyperbola whose equation is—

$$xy=\text{constant}.$$

To find the mean pressure between two points on the curve find the area of the part of the curve included between the ordinates at those points. On doing this the following formula is arrived at:—

$$\text{P}m=\text{P}_1\left(\frac{1+\text{hyp. log. V}}{\text{V}}\right)-p.$$

Where P_1 = absolute initial pressure of steam

(= gauge pressure + 14·7 lbs. per square inch)

hyp. log. = hyperbolic logarithm.

V = volume after expansion ÷ volume before expansion *or* pressure before expansion ÷ pressure after expansion,

P = back pressure = about 4 lbs. per square inch for condensing engines, and 17 lbs. in non-condensing engines.

P_m = mean pressure.

PADDLE WHEELS.

Paddle-wheel Feathering.—To find diameter:

Let S = speed of ship in knots per hour; then

$$S \times \frac{6080}{60} = \text{speed per minute.}$$

S_1 = slip of ship in knots per hour; then

$$S_1 \times \frac{6080}{60} = \text{slip per minute.}$$

D = diameter of wheel between centres, and

R = revolutions per minute.

The velocity of wheel at centres

$$= \frac{6080}{60}(S + S_1) = \pi \times D \times R.$$

$$\therefore D = \frac{101(S + S_1)}{\pi \times R}.$$

Area of one float in square feet $= \dfrac{\text{IHP} \times 33{,}000 \times K}{N \times (D \times R)^3}$

Where D = diameter of wheel to axes of floats, in feet.

N = number of floats in one wheel.

R = number of revolutions per minute.

K = (for vessels in smooth water) 1,200.
(for vessels at sea) 1,400.
(for tugs) 1,600.

Number of floats $= \dfrac{60}{\sqrt{R}}$. Breadth of float = ·35 × length.

Thickness of wood float $= \frac{1}{12}$ breadth.

Thickness of steel float $= (\cdot 16 \times \text{breadth in feet}) + \cdot 15$ in inches.

Efficiency of common wheel = efficiency of feathering wheel

$$\sqrt{\frac{\text{height of centre of wheel above water}}{\text{outer radius of wheel}}}.$$

Number of floats in common wheel = D.

SCREW PROPELLERS.

Screw Propeller.—Let D = diameter of blades, P = pitch of screw in feet; then thrust varies as $D^2 \times R^2 \times P^2$, and IHP varies as thrust $\times R \times P$, or varies as $D^2 \times R^3 \times P^3$.

$\therefore$ IHP $= k \times D^2 \times R^3 \times P^3$, where k is some constant.

$$\therefore \; D = 20000 \sqrt{\frac{IHP}{R^3 \times P^3}}, \text{ and } P = 737 \sqrt[3]{\frac{IHP}{R^3 \times D^2}}.$$

EXAMPLE.—To find the diameter of the screw for a steam launch whose engines develop 200 IHP when working at 300 revolutions:

$$D = 25000 \sqrt{\frac{200}{(6 \times 300)3}} = 4 \cdot 6 \text{ feet.}$$

Area of Screw Blade.—The best area can only be determined by actual experiment, but the following rule will give good results:—

$$\text{Total area of blades} = k \sqrt{\frac{IHP}{R}};$$

where R = number of revolutions; $k = 15$ for 4-bladed propellers, 13 for 3-bladed, and 10 for 2-bladed propellers.

$$\textit{Greatest breadth of blade} = k \sqrt[3]{\frac{IHP}{R}};$$

where $k = 14$, 17, and 22, for 2, 3, and 4-bladed propellers respectively.

Twin Screws.—Make the pitch, diameter, and all other dimensions $= \frac{1}{\sqrt{2}}$ that required for a single screw to answer the same purpose; and revolutions of twin screw $= \sqrt{2}$ revolutions of single screw per minute.

RELATIVE CORROSION OF IRON IN SEA WATER.

Iron by itself	1·000.
„ in contact with brass .	3·434.
„ „ „ copper .	4·958.
„ „ „ lead .	5·550.
„ „ „ gun metal	6·534.
„ „ „ tin . .	8·657.

DIFFERENCE IN DRAUGHT OF WATER WHEN AT SEA AND IN THE RIVER.

W = displacement of ship in tons.

D = displacement per inch in tons at load water-line in sea water.

I = increase of draught of water in river in ins.

$$I = \frac{W}{63 \times D}$$

SLIP OF SCREW OR PADDLE.

V = velocity of centre of floats or speed of screw in feet per second.

v = velocity or speed of ship in feet per second.

S = slip per cent.

$$S = 100\frac{V - v}{V} \qquad V = \frac{100v}{100 - S}$$

Note.—Speed of screw in feet per second = pitch × revolutions.

FREE-BOARD.

Lloyd's old rule allows 2 ins. free-board per foot depth of hold plus $\frac{1}{10}$ in. more for every extra foot depth above 8 feet.

Mr. Barnaby's rule allows one-eighth the beam, with the addition of one-thirty-second part of the beam, for every beam in the length of the ship above five beams.

SURVEYOR'S RULE FOR APPROXIMATE REGISTER TONNAGE.

(*See also 'Register Tonnage,' p.* 527.)

G = girth in feet. B = breadth in feet. L = length in feet.

R = approximate gross register tonnage.

$$R = \frac{17}{10000}\left(\frac{G+B}{2}\right)^2 \times L \text{ for wood and composite ships,}$$

$$R = \frac{18}{10000}\left(\frac{G+B}{2}\right)^2 \times L \text{ for iron ships.}$$

PILE-DRIVING. (*Rankine.*)

P = greatest load the pile has to bear in tons.
W = weight of ram in tons.
H = height of fall of ram in feet.
L = length of pile in feet.
D = depth driven by last blow in decimals of a foot.
A = sectional area of pile in square inches.
k = constant depending on kind of material.

$$P = \sqrt{\left(\frac{4AWHk}{L} + \frac{4A^2D^2k^2}{L^2}\right)} - \frac{2ADk}{L}$$

$$WH = \frac{P^2L}{4Ak} + PD \qquad D = \frac{WH}{P} - \frac{PL}{4Ak}$$

k = 400 to 600 for elm.
k = 500 for alder and sycamore.
k = 500 to 600 for greenheart.
k = 600 for beech.
k = 1000 for teak.

SPEED OF CUTTING TOOLS.

For cast iron, 150–190 inches per minute; boring, 80 inches per minute.

For wrought iron, 260–280 inches per minute.

For yellow brass, 300 inches per minute.

WEIGHT OF WROUGHT IRON GAS TUBING OF FAIR QUALITY, PER 1,000 LINEAL FEET.

Bore	Weight	Bore	Weight	Bore	Weight
In.	Cwt.	In.	Cwt.	In.	Cwt.
1/8	2·5	1	16·0	2¼	47·5
1/4	3·66	1¼	22·5	2½	59·6
3/8	5·41	1½	26·5	2¾	75·0
1/2	7·77	1¾	35·0	3	82·5
3/4	10·5	2	40·0	—	—

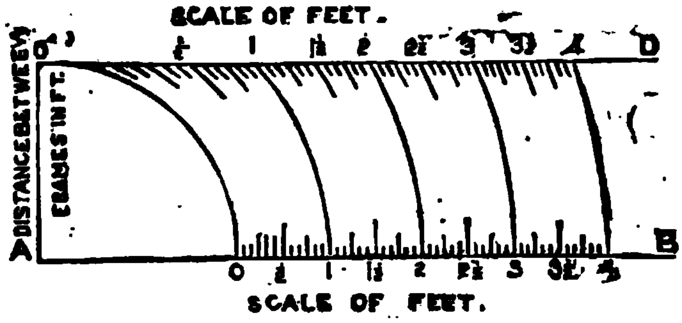
TO CONSTRUCT A SCALE FOR TAKING AN EXPANSION FROM THE BODY PLAN OF A SHIP (fig. 314).

(*C. W. Merrifield, Esq.*)

Set off a base line AB, and at the end set up a perpendicular AO equal to the perpendicular distance between the frames in

feet and inches; then through 0 draw 0D parallel to AB; then from A as centre and 0A as radius describe the quadrant 00, cutting AB in 0; then from 0 set off towards B a scale of equal parts in feet and inches, as 0, ½, 1, 1½, &c.; then with A as centre describe the scale 04 on AB, on to the line 0D: if the edge 0D of the scale be then applied at the given point on the body plan perpendicular to the lines of the frames, the distance between the two frames at that point measured on the scale will give the *actual* distance between the frames in *space* in feet and inches.

FIG. 314.



DIAMETER OF A WROUGHT IRON DAVIT.

Let D = required diameter of davit in inches.

h = overhang of davit in inches.

p = stress in tons per square inch which can be allowed on davit. In Government work p is generally taken as 2½.

W = the greatest weight in tons the davit will have to support.

Then $D^3 = \dfrac{32\,Wh}{\pi p}$

COLOURS FOR WORKING DRAWINGS.

Material.	Representative Colour.
Brass . .	gamboge or chrome yellow.
Brick-work .	crimson lake or carmine.
Cast iron .	neutral tint or Payne's grey.
Clay or earth	burnt umber.
Concrete .	sepia with dark markings.
Copper . .	carmine or lake mixed with burnt sienna.
Granite . .	pale Indian ink.
Lead . .	Indian ink tinged with Prussian blue.
Steel . .	pale blue tinged with lake or carmine.
Water . .	cobalt or verdigris.
Woods . .	burnt sienna, or raw sienna for light woods.
Wrought iron	Prussian blue or indigo.

Note.—The usual method is to colour at least all the sectional parts; when both parts are coloured the sectional are coloured much darker than the other parts.

Circular Speed for Saws in Revolutions per Minute.					
Diam. of Saw in Ins.	Revls. for Thin Saws	Revls. for Thick Saws	Diam. of Saw in Ins.	Revls. for Thin Saws	Revls. for Thick Saws
10	2,900	3,000	25	1,400	2,100
15	1,800	2,700	30	1,200	1,800
20	1,500	2,400	36	1,000	1,500

Thermometers.

F = Fahrenheit. R = Réamur. C = Centigrade.

$$C = \frac{5(F-32)}{9} = \frac{5R}{4} \qquad R = \frac{4(F-32)}{9} = \frac{4C}{5} \qquad F = \frac{9R}{4} + 32 = \frac{9C}{5} + 32.$$

Table giving the Breaking Strain of Tiller Ropes.															
Hide Ropes								White Ropes							
Cir.	Breaking Strain			Cir.	Breaking Strain			Cir.	Breaking Strain			Cir.	Breaking Strain		
Ins.	T.	Cwt.	Qr.	Ins.	T.	Cwt.	Qr.	Ins.	T.	Cwt.	Qr.	Ins.	T.	Cwt.	Qr.
$2\frac{1}{2}$	1	5	2	$4\frac{1}{2}$	4	2	2	$2\frac{1}{2}$	2	6	0	$4\frac{1}{2}$	7	8	2
3	1	16	3	5	5	2	0	3	3	6	0	5	9	3	2
$3\frac{1}{2}$	2	10	0	$5\frac{1}{2}$	6	3	2	$3\frac{1}{2}$	4	10	0	$5\frac{1}{2}$	11	2	1
4	3	5	0	—		—		4	5	17	2	—		—	

Number of Shot in Piles.

In a triangular pile $= \frac{1}{6}\{n(n+1) \times (n+2)\}$ = number; when n = number in each side of base.

In a square pile $= \frac{1}{6}\{n(n+1) \times (2n+1)\}$ = number; when n = number in each side of base.

In a rectangular pile $= \frac{1}{6}\{3N - (n-1) \times (n+1) \times n\}$ = number; when N = number in longest side of base and n = number in shortest side of base.

Diameter of Iron for Shackles to Chains.

(Admiralty Rule.)

For $\frac{3}{4}$ to $1\frac{1}{4}$ inch chain, the iron in shackles to be $\frac{1}{4}$ inch more in diameter than the chain.

For $\frac{11}{16}$ inch chain, use a $\frac{7}{8}$ inch shackle.

For $\frac{5}{16}$ to $\frac{5}{8}$ inch chain, the iron in shackles to be $\frac{1}{8}$ inch more in diameter than the chain.

For $\frac{9}{32}$ inch chain, use a $\frac{3}{8}$ inch shackle, for a $\frac{1}{4}$ inch chain use a $\frac{5}{16}$ inch shackle, and for an $\frac{1}{8}$ inch chain use a $\frac{1}{4}$ inch shackle.

TABLE OF PERCENTAGES TO BE ADDED TO THE CALCULATED WEIGHTS OF FLUSH-JOINTED PLATING ON ACCOUNT OF EDGE STRIPS AND BUTT STRAPS.

		Plates 16 ft. long. Butt Straps full breadth of Plates				Plates 16 ft. × 3 ft. 3 ins. wide. Percentages applicable to Deck Plating, Inner Bottom Plating, Flush-jointed Bulkheads, &c.								
		Percentages applicable to Vertical Keel, Longitudinals, Stringers, &c.				Double-riveting for both Edges and Butts			Single-riveted Edges and Double-riveted Butts			Single-riveting for both Edges and Butts		
Thickness of Plates in Inches	Diameter of Rivets in Inches	Treble-riveted Double Straps, each $\frac{1}{16}$ in. more than half the thickness of the plate. Width of Straps, 16½ diams.	Treble-riveted Double Straps, each half the thickness of the plate. Width of Straps, 16½ diams.	Double-riveted Double Straps, each half the thickness of the plate. Width of Straps, 11½ diams.	Single-riveted Double or Single Straps. If double, each Strap half the thickness of the plate. Width of Straps, 6½ diams.	Double-riveted Edge Strips, 11½ diameters wide	Double-riveted Butt Straps, when on opposite side to Edge Strips, 11½ diameters wide.	Double-riveted Butt Straps, when on same side as Edge Strips, 11½ diameters wide	Single-riveted Edge Strips, 6½ diameters wide	Double-riveted Butt Straps, when on opposite side to Edge Strips, 11½ diameters wide	Double-riveted Butt Straps, when on same side as Edge Strips, 11½ diameters wide	Edge Strips 6½ diameters wide	Butt Straps on opposite side to Edge Strips, 6½ diameters wide	Butt Straps on same side as Edge Strips, 6½ diameters wide
1	1¼	12·08	10·74	7·48	4·23	35·26	7·48	4·85	20·83	7·49	5·94	20·83	4·23	3·36
⅞	1⅛	11·05	9·67	6·74	3·81	31·74	6·74	4·60	18·75	6·74	5·48	18·75	3·81	3·10
¾	1	10·03	8·60	6·00	3·40	28·21	6·00	4·30	16·67	6·00	5·00	16·67	3·40	2·83
⅝	⅞	9·02	7·52	5·24	3·00	24·68	5·24	3·92	14·58	5·24	4·45	14·58	3·00	2·52
½	¾	8·05	6·44	4·49	2·54	21·15	4·49	3·54	12·49	4·49	3·93	12·49	2·54	2·23
⅜	⅝	7·16	5·37	3·75	2·12	17·63	3·75	3·06	10·42	3·75	3·38	10·42	2·12	1·91
¼	½	6·44	4·29	3·00	1·70	14·10	3·00	2·57	8·33	3·00	2·74	8·33	1·70	1·55

TABLE OF PERCENTAGES TO BE ADDED TO THE CALCULATED WEIGHTS OF LAPPED PLATING ON ACCOUNT OF LAPS, BUTT STRAPS, AND LINERS.

Applying to Bottom Plating, Lap-jointed Bulkheads, &c.

Thickness of Plates in Inches	Diameter of Rivets in Inches	Plates 12 Feet Long and 3 Feet Wide							Plates 16 Ft. Long and 3 Ft. Wide				Plates 16 Feet Long and 3 Ft. 3 In. Wide		
		Double-riveted Edges and Double-riveted Butts			Single-riveted Edges and Single- or Double-riveted Butts				Single-riveted Edges and Single- or Double-riveted Butts				Single-riveted Edges and Single-riveted Butts		
		Double-riveted Laps, 5½ diameters wide	Double-riveted Butt Straps, 11½ diameters wide	Liners (including Wide Liners at Water-tight Frames and Bulkheads)	Single-riveted Laps, 3½ diameters wide	Double-riveted Butt Straps, 11½ diameters wide	Single-riveted Butt Straps, 6½ diameters wide	Liners (including Wide Liners at Water-tight Frames and Bulkheads)	Single-riveted Laps, 3½ diameters wide	Double-riveted Butt Straps, 11½ diameters wide	Single-riveted Butt Straps, 6½ diameters wide	Liners (including Wide Liners at Water-tight Frames and Bulkheads)	Single-riveted Laps, 3½ diameters wide	Single-riveted Butts, 3½ diameters wide	Liners to Stiffeners, 2 ft. 6 ins. apart
1	1¼	23·60	7·91	4·18	12·72	8·85	5·00	5·24	12·72	6·64	3·75	5·24	10·47	2·12	4·20
7/8	1⅛	20·75	7·35	4·45	11·30	8·07	4·57	5·39	11·30	6·05	3·43	5·39	9·38	1·91	4·32
3/4	1	18·03	6·78	4·71	9·92	7·27	4·10	5·55	9·92	5·45	3·08	5·55	8·34	1·70	4·44
5/8	7/8	15·43	6·07	4·98	8·56	6·42	3·63	5·70	8·56	4·82	2·73	5·70	7·29	1·46	4·56
1/2	3/4	12·94	5·32	5·24	7·26	5·59	3·16	5·85	7·26	4·19	2·37	5·85	6·25	1·27	4·68
3/8	5/8	10·58	4·50	5·51	5·97	4·70	2·66	6·01	5·97	3·52	2·00	6·01	5·21	1·06	4·81
1/4	1/2	8·27	3·69	5·75	4·73	3·81	2·16	6·17	4·73	2·86	1·62	6·17	4·17	·85	4·94

COMPARATIVE TABLE OF ELEMENTS OF FIVE-TON YACHTS.*

—	Design	'Freda'	'Cocker'	'Lorelei'	'Olga'
	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.
Length on deck, stem to sternpost	33 10	31 4	34 8	31 6	—
Length on load water line	32 0	30 4	32 0	31 6	32 8
Rake of sternpost from plumb-line (4ft. in length)	2 3	1 8	4 2	2 5	—
Breadth moulded	5 10	5 11¼	5 9⅝	5 10	—
Breadth extreme	6 0	6 1¼	5 11⅜	6 0	5 9
Extreme draught of water	6 2	5 5½	5 9	5 4	6 8
Draught of water 4 feet abaft foreside of stem at L.W.L.	3 2	4 0	3 4	2 11	—
Mean draught of water .	4 11	4 7	4 9	4 8	—
Area of load water-plane	132 sq. ft.	124 sq. ft.	128 sq. ft.	134 sq. ft.	114 sq. ft.
Area of midship section .	18·8 sq. ft.	16 sq. ft.	15·8 sq. ft.	14·8 sq. ft.	19 sq. ft.
Area of vertical longitudinal section	157 sq. ft.	149 sq. ft.	152 sq. ft.	132 sq. ft.	156 sq. ft.
Area of immersed surface	360 sq. ft.	358 sq. ft.	360 sq. ft.	318 sq. ft.	355 sq. ft.
Area of canvas for square foot of wetted surface .	2·34 sq. ft.	2·24 sq. ft.	—	2·47 sq. ft.	2·77 sq. ft.
Displacement in tons . .	9·2 tons	7·7 tons	8·2 tons	7·5 tons	10·2 tons
Displacement per inch of immersion at L.W.L. . .	6¼ cwt.	6 cwt.	6 cwt.	6¼ cwt.	—
Coefficient of displacement	·341	·322	·308	·3294	—
Midship section abaft centre of length of L.W.L.	1·5 ft.	1·2 ft.	1·1 ft.	1·9 ft.	—
Centre of buoyancy ditto	1 ft.	0·4 ft.	1·5 ft.	0·8 ft.	1·44 ft.
Centre of lateral resistance ditto	2 ft.	1·1 ft.	1 ft.	1·4 ft.	1·05 ft.
Centre of effort of lower sails ditto	1·4 ft.	0·5 ft.	0·5 ft.	0·5 ft.	0·5 ft.
Centre of buoyancy below L.W.L.	1·66 ft.	1·44 ft.	1·5 ft.	1·37 ft.	1·76 ft.
Centre of lateral resistance ditto	2·6 ft.	2·2 ft.	2·2 ft.	2·2 ft.	—
Metacentre above centre of buoyancy	0·81 ft.	1 ft.	·93 ft.	1·1 ft.	·76 ft.
Centre of effort of sails above L.W.L.	15·5 ft.	15 4 ft.	14·8 ft.	14·3 ft.	—
Ballast inside	1 ton	2 tns. 14 ct.	—	—	—
Ballast outside	5¼ tons	1ton 18cwt.	5 tons	4tons 3cwt.	7 tons
Total ballast	6¼ tons	4 tns. 12 ct.	5 tons	4tons 3cwt.	7 tons
Tonnage Y.R.A.	$4\frac{80}{94}$	$4\frac{76}{94}$	$4\frac{93}{94}$	$4\frac{84}{94}$	—
Mast, deck to hounds . .	21 ft. 0 in.	20 ft. 6 in.	22 ft. 9 in.	22 ft. 0 in.	—
Masthead	4 6	4 0	4 0	4 0	—
Diameter at deck	5½ in.	5¼ in.	6½ in.	0 5½	—
Main boom	29 0	29 6	28 0	27 0	—
Greatest diameter . . .	5½ in.	5¼ in.	5½ in.	0 5½	—
Gaff	20 8	19 0	19 0	19 0	—
Bowsprit outboard . . .	12 6	15 0	17 0	14 0	—
Diameter at stem	4¾ in.	5¼ in.	5¼ in.	0 5	—
Topmast, fid to hounds .	19 6	18 6	21 0	20 0	—
Topsail yard	19 0	18 0	30 0	—	—
Spinnaker boom	34 0	35 0	34 0	33 0	—
Centre of mast from foreside of stem on deck . .	13 3	12 4	13 6	12 0	—
Luff of mainsail	17 9	17 3	20 0	18 0	—
Leech of mainsail . . .	35 0	34 6	37 0	32 0	—
Angle of gaff with horizontal	58°	51°	53°	51°	—
Area of mainsail	564 sq. ft.	530 sq. ft.	604 sq. ft.	526 sq. ft.	687 sq. ft.
Area of foresail	120 sq. ft.	110 sq. ft.	138 sq. ft.	104 sq. ft.	140 sq. ft.
Area of jib	150 sq. ft.	160 sq. ft.	221 sq. ft.	139 sq. ft.	170 sq. ft.
Total area lower sail . .	834 sq. ft.	800 sq. ft.	963 sq. ft.	769 sq. ft.	997 sq. ft.

* From Dixon Kemp's 'Yacht Architecture.'

Comparative Table of Elements of Ten-tonners.*

—	Design	'Lily'	'Saraband'	'Buttercup'
	ft. in.	ft. in.	ft. in.	ft. in.
Length on deck, stem to sternpost . . .	42 3	37 9½	48 6	–
Length on load water line	40 0	36 6¾	41 0	42 2
Rake of sternpost from plumb line, 4ft. in length	2 3	2 1	2 10	—
Breadth moulded . .	7 4½	7 10½	7 1½	—
Breadth extreme . .	7 7½	8 1	7 3¼	7 3
Extreme draught of water	7 10	6 9	7 9	7 9
Mean draught of water	6 3½	5 11	6 6	—
Area of load water-plane	209 sq. ft.	200 sq. ft.	185 sq. ft.	—
Area of midship section	29 sq. ft.	21·2 sq. ft.	32·5 sq. ft.	—
Area of vertical longitudinal section . .	245 sq. ft.	216 sq. ft.	257 sq. ft.	—
Area of immersed surface	550 sq. ft.	530 sq. ft.	578 sq. ft.	—
Area of canvas per sq. ft. of wetted surface .	2·33 sq. ft.	2·06 sq. ft.	2·94 sq. ft.	—
Displacement in tons .	18 tons	13 tons	21 tons	22 tons
Midship section abaft centre of length of LWL	1·9 ft.	1·45 ft.	Raked	—
Centre of buoyancy ditto	1·25 ft.	0·96 ft.	1·7 ft.	—
Centre of lateral resistance ditto . . .	2·5 ft.	1·35 ft.	1·7 ft.	—
Centre of effort of lower sails ditto . . .	1·7 ft.	1·5 ft.	0·4 ft.	—
Centre of buoyancy below L.W.L. . . .	2·07 ft.	1·65 ft.	2·6 ft.	—
Centre of lateral resistance ditto . . .	3·25 ft.	—	3·2 ft.	—
Metacentre above centre of buoyancy . .	1·1 ft.	1·76 ft.	0·76 ft.	—
Centre of effort of sails above L.W.L. . .	19·4 ft.	18·9 ft.	20 ft.	19·5 ft.
Ballast inside . .	10 cwt.	2 tons 12 cwt.	10 cwt.	1½ ton
Ballast outside . .	11 tons	4 tons 3 cwt.	11 tons	12 tons
Total ballast . . .	11 tons 10 ct.	6 tons 15 cwt.	11 tons 10 ct.	13½ tons
Tonnage Y.R.A. . .	9·95 tons	9·6 tons	9·8 tons	10·44 tons
Mast, deck to hounds .	29 0	25 0	30 0	30 0
Masthead . . .	5 3	—	6 3	—
Diameter at deck . .	8½ in.	6¾ in.	8¾ in.	—
Main boom . . .	38 6	30 6	39 6	39 0
Greatest diameter .	7 in.	5¾ in	7½ in.	—
Gaff	25 0	23 0	25 6	25 0
Bowsprit outboard .	19 0	17 0	19 9	20 6
Diameter at stem .	7 in.	6½ in.	7½ in	—
Topmast, fid to hounds.	27 0	24 0	27 6	27 0
Topsail yard . . .	30 0	—	27 0	—
Spinnaker boom . .	40 0	—	41 0	38 0
Centre of mast from fore side of stem at deck .	15 0	15 5	18 6	17 4
Luff of mainsail . .	26 0	—	26 6	—
Leech of mainsail. .	44 0	—	51 ft.	—
Angle of gaff with horizontal	53°	53°	53°	53°
Area of mainsail . .	910 sq. ft.	722 sq. ft.	1120 sq. ft.	1080 sq. ft.
Area of foresail . .	180 sq. ft.	162 sq. ft.	250 sq. ft.	220 sq. ft.
Area of working jib .	230 sq. ft.	211 sq. ft.	320 sq. ft.	330 sq. ft.
Total area of lower sail	1320 sq. ft.	1095 sq. ft.	1690 sq. ft.	1630 sq. ft.

* From Dixon Kemp's 'Yacht Architecture.'

Table of Factors used to Determine the Diameters of Ships' Masts and Spars.

	Species of Masts and Spars	Given Diamr. = Whole Length ×	End Diameters = Given Diameter ×	
Lower masts	Ships', brigs', and barques'	·025 to ·028	heel	·833
			hounds	·800
			head	·755
	Cutters'	·020 „ ·021	heel	·833
			hounds	·750
			head	·500
	Schooners'	·020 „ ·022	heel	·833
			hounds	·800
			head	·670
	Luggers'	·020 „ ·021	heel	·933
			hounds	·750
			head	·583
Topmasts	Ships', brigs', and barques'	·023 „ ·025	hounds	·800
			head	·690
	Cutters' and schooners'	·020 „ ·022	hounds	·771
			head	·500
	Luggers'	·020 „ ·021	hounds	·771
			pole	·500
	Topgallant masts	·020 „ ·021	hounds	·771
			skysail pole	·500
Bowsprit	Ships', brigs', and barques'	·040 „ ·050	heel	·833
			head	·666
	Cutters' and schooners'	·040 „ ·050	heel	1·000
			head	·666
Yards	Lower yard	·020 „ ·025	yard arms*	·500
	Topsail yard	·017 „ ·020	„	·500
	Topgallant and royal yard	·017 „ ·018	„	·500
	Cross jack yard	·020 „ ·025	„	·500
	Cutters' and schooners' square sail	·014 „ ·017	„	·500
	Cutters' and schooners' topsail	·017 „ ·020	„	·500
	Luggers' yards	·018 „ ·023	„	·500
Booms	Driver boom	·017 „ ·020	outer end	·75
			inner „	·66
	Main and cutters' booms	·017 „ ·020	outer „	·75
			inner „	·71
	Jibboom	·020 „ ·025	outer „	·75
			inner „	1·00
	Flying jibboom	·017 „ ·020	outer „	·66
			inner „	·75
	Jib and flying jibboom in one	·022 „ ·026	outer „	·66
			inner „	·50
Gaffs	Ships' and brigs'	·018 „ ·022	outer end	·50
	Cutters' and schooners'	·018 „ ·022	„	·60
	Trysail gaffs	·030 „ ·040	„	·60

Note.—The factors in the above table will apply equally well whether the masts and spars are of wood or of iron.

TABLE OF POSITION AND RAKE OF MASTS FOR SAILING VESSELS.

RIG AND NAMES OF MASTS		Distance from Middle of Water Line in Fractions of the Length of that Line		Rake in Twelve Feet
		Before	Abaft	Inches
Frigate	main mast	—	·062 to ·069	6 to 5
	fore "	·37 to ·39	—	2 to 1
	mizen "	—	·341 to ·404	10 to 9
Corvette	main "	—	·096 to ·06	6 to $10\frac{1}{2}$
	fore "	·372 to ·399	—	2 to $1\frac{3}{4}$
	mizen "	—	·375 to ·356	10 to $10\frac{3}{4}$
Clipper ship	main "	—	·047	9
	fore "	·274	—	3
	mizen "	—	·309	15
Lugger	main "	—	·04	·12
	fore "	·396	—	·6
	mizen "	—	·396	·24
Barque	main "	—	·067	13
	fore "	·300	—	11
	mizen "	—	·349	17
3-masted schooner	main "	—	·033	27
	fore "	·295	—	24
	mizen "	—	·366	30
Common schooner	main "	—	·046	24
	fore "	·338	—	15
Bermuda schooner	main "	—	·108 to ·084	24 to 33
	fore "	·279 to ·31	—	16 to 36
Brig of war	main "	—	·147 to ·138	10 to 9
	fore "	·331 to ·323	—	3 to 2
Yacht as brig	main "	—	·144	10
	fore "	·323	—	$2\frac{1}{2}$
Ketch	main "	·11	—	12
	mizen "	—	·395	18
Revenue cutter	main "	·13 to ·104	—	14 to 13
Cutter yacht	main "	·112 to ·14	—	12 to 15

TABLE FOR SAILING SHIPS, SHOWING THE PROPORTIONS WHICH THE DIAMETER OF CHAIN RIGGING AND THE GIRTHS OF HEMP OR WIRE RIGGING SHOULD BEAR TO THE DIAMETERS OF THE MASTS, YARDS, &c., FROM WHICH THE RIGGING LEADS.*

	Parts of Rigging	Ratios
Fore and main masts	Pendants	·375
	Shrouds†	·188
	Stays	·282
	Ratlines	·057
Fore and main yards	Foot-ropes	·300
	Stirrups	·250
	Lifts	·250
	Braces	·250
	Tacks	·300
	Sheets	·300
	Clew garnets	·200
	Bowlines	·250
	Bridles	·250
	Buntlines	·200
	Leechlines	·150
	Slabline	·120
	Fore staysail stay †	·282
	Halliards	·200
	Sheets	·200
	Tack lashing	·150
	Downhaul	·150
	Lower studding sail:—	
	Halliards	·200
	Inner halliards	·200
	Sheets and tack	·200
Fore and main topmasts	Shrouds †	·188
	Ratlines	·065
	Backstays †	·225
	Burton pendants	·300
	Stays	·225
	Futtock shrouds §	·030
	Ratlines	·057
	Staysail halliards	·200
	Downhaul	·160
	Pendants	·300
Fore and main topsail yards	Sheets ‡	·050
	Topsail tyes	·050
	Halliards	·250
	Foot-ropes	·300
	Stirrups	·250
	Flemish horses	·208
Fore & main topsail yards (concld.)	Braces	·250
	Lifts	·300
	Parrel rope	·333
	Clewlines	.300
	Buntlines	·250
	Bowlines	·250
	Reef tackles	·250
	Sheets ‡	·050
	Studding-sail halliards	·300
	Sheets	·300
	Tacks	·300
	Downhaul	·200
	Boom jiggers	·200
	Heel lashing	·250
	Boom-brace pendant	·291
	Whip	·167
Fore and main topgallant masts	Shrouds †	·225
	Backstays	·225
	Stay †	·225
	Royal stay †	·115
	Backstay †	·115
Fore & main topgallant yards	Halliards and strapping	·400
	Foot-ropes	·300
	Braces and strapping	·250
	Lifts	·350
	Parrel ropes	·333
	Clewlines	·220
	Bowlines	·220
	Bridles	·250
	Sheets	·400
	Studding sail halliards	·220
	Sheets	·220
	Tacks	·220
	Downhaul	·200
Fore and main royal yards	Halliards	·400
	Foot-ropes	·300
	Braces and strapping	·250
	Lifts	·350
	Parrel lashing	·167
	Clewlines & bowlines	·220
	Sheets	·400

* All the rigging is of hemp, except that marked otherwise.
† Wire-rope rigging. ‡ Chain rigging. § Iron rods.

Table for Sailing Ships, showing the Proportions of Chain and Hemp and Wire-rope Rigging in Relation to the Masts and Spars (concluded).*

	Parts of Rigging	Ratios
Mizen mast	Shrouds †	·146
	Burton pendants	·250
	Ratlines	·069
	Stay †	·174
	Seizings †	·027
Cross-jack yard	Foot-ropes	·300
	Stirrups	·250
	Lifts	·250
	Braces & strapping	·250
Mizen topmast	Shrouds †	·188
	Stay †	·225
	Ratlines	·056
	Backstays †	·156
	Futtock shrouds §	·030
Mizen topsail yard	Topsail tyes ‡	·050
	Halliards for do.	·225
	Foot-ropes	·300
	Stirrups	·250
	Flemish horses	·300
	Parrel rope	·333
	Lifts	·300
	Braces	·250
	Sheets ‡	·050
	Clewlines	·300
	Buntlines	·250
	Span	·250
	Bowlines	·250
	Bridles	·250
	Reef tackles	·250
Mizen topgallant mast	Shrouds †	·225
	Backstays †	·225
	Stay †	·225
	Royal stay †	·113
	Backstays †	·113
Mizen topgallant yard	Foot-ropes	·300
	Parrel lashing	·231
	Lifts	·350
	Halliards	·400
	Sheets	·400
	Clewlines	·222
	Bowlines	·222
	Bridles	·250
	Strapping, ¼-blocks	·308
Mizen royal yard	Foot-ropes	·300
	Braces and strapping	·250
	Parrel lashing	·100
	Lifts	·350
	Halliards	·400
	Sheets	·400
	Clewlines	·220
Spanker boom	Topping lifts	·400
	Falls and strapping	·300
	Boom sheet	·400
	Outhauler	·400
	Guy pendants	·400
	Falls	·300
	Strapping to do.	·300
Gaff	Throat halliards	·400
	Peak halliards	·400
	Vang pendants	·350
	Falls and strapping	·200
	Peak brails	·200
	Throat brails	·200
	Middle brails	·200
	Hook brails	·200
Bowsprit	Gammoning ‡	·028
	Shrouds ‡	·028
	Bobstays ‡	·033
	Man-ropes	·133
Jibboom	Jibstay †	·200
	Guys, single †	·200
	Foot-ropes	·250
	Martingale stay †	·250
	Martingale backropes †	·175
	Halliards	·240
	Downhaul	·200
	Sheets	·240
	Pendants	·321
Flying jibboom	Flying-jib stay †	·175
	Guys †	·175
	Foot-ropes	·300
	Martingale stay †	·200
	Halliards and strapping	·250
	Downhaul and strapping	·200
	Sheets	·250
	Heel lashing	·250

* All the rigging is of hemp, except that marked otherwise.
† Wire-rope rigging. ‡ Chain rigging. § Iron rods.

Note.—Girth of any lanyard = girth of rope set up by it × ·5.

ABLE OF THE WEIGHT OF VESSELS' MASTS, SPARS, RIGGING, AND SAILS IN TONS.

Kind of Vessel	Sailing Ships				
Tonnage (B.M.)	2,600	2,200	1,700	1,400	1,000
ower masts and bowsprit*	52·6	51·9	30·7	34·1	21·6
opmasts and yards	37·1	36·0	27·5	26·5	18·6
pare gear and booms	16·5	16·0	12·6	12·0	7·5
tanding rigging †	22·0	21·2	20·2	19·1	11·0
unning "	18·1	17·2	16·9	16·3	11·4
locks to "	12·2	11·1	10·6	10·0	5·4
hip's sails	6·9	7·3	6·0	6·1	3·8
pare "	4·2	4·4	3·7	3·4	2·3
Kind of Vessel	**Sailing Ship**	**Brigs**		**Schooner**	**Cutter**
Tonnage (B.M.)	**500**	**380**	**280**	**180**	**160**
ower masts and bowsprit	9·1	7·5	4·3	6·4	5·5
opmasts and yards	8·8	7·2	5·8	1·9	2·6
pare gear and booms	4·1	3·0	2·2	1·2	—
Standing rigging †	9·4	3·8	2·4	1·9	1·7
Running "	6·5	4·5	2·8	1·4	1·3
Blocks to "	4·2	2·0	1·0	·3	·2
Ship's sails	2·1	1·5	1·2	1·3	1·8
Spare "	1·5	1·2	·85	·8	·25

* The masts and spars are all of wood. † Standing rigging of wire.

TABLE OF THE RELATIVE PROPORTIONS OF IRON AND HEMPEN CABLES, TOGETHER WITH THEIR WEIGHT.

of Chain	Girth of Hemp	Weight of 100 Fathoms: Chain			Weight of 100 Fathoms: Hemp		
ns.	Ins.	Cwt.	Qr.	Lb.	Cwt.	Qr.	Lb.
¾	7½	29	0	17	10	2	9
	8				12	0	26
	8½				13	3	16
⅞	9	39	1	21	15	2	25
	9½				17	0	22
1	10	50	0	14	19	0	21
	10½				21	0	20
1⅛	11	65	3	5	23	1	0
	11½				25	0	15
	12				27	1	23
	12½				29	3	3
1¼	13	81	3	12	32	1	19
	13½				35	0	7
1⅜	14	94	0	7	37	2	4
	14½				40	1	12

Diamr. of Chain	Girth of Hemp	Weight of 100 Fathoms: Chain			Weight of 100 Fathoms: Hemp		
Ins.	Ins.	Cwt.	Qr.	Lb.	Cwt.	Qr.	Lb.
1½	15	110	0	14	43	0	1
	15½				45	3	27
	16				48	3	24
1⅝	16½	136	2	10	51	3	2
	17				55	1	0
1¾	17½	155	0	9	58	2	6
	18				61	3	13
1⅞	18½	180	3	14	65	2	1
	19				69	0	17
	20				76	3	1
2	21	190	0	14	84	1	14
	22				92	2	16
2⅛	23	216	0	0	101	2	8
	24				110	2	1
	25				119	3	2

Table Giving the Girths of Hemp and Wire Rope of Equivalent Strengths.

Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.)	Hemp (ins.)	Wire (ins.
12	4⅝	10¼	4⅛	8½	3⅝	6¾	2¾	5	2	3¼	1⅜
11¾	—	10	4	8¼	3½	6½	2⅝	4¾	—	3	1¼
11½	4½	9¾	—	8	3⅜	6¼	2½	4½	1⅞	2¾	1⅛
11¼	—	9½	3⅞	7¾	3¼	6	2⅜	4¼	—	2½	1
11	4⅜	9¼	—	7½	3⅛	5¾	2¼	4	1¾	2¼	⅞
10¾	—	9	3¾	7¼	3	5½	2⅛	3¾	1⅝	2	¾
10½	4¼	8¾	—	7	2⅞	5¼	—	3½	1½	1¾	⅝

Table Showing from what Numbers of Canvas the Different Sails are Made.

No. of Canvas	Species of Sails made of the given Number of Canvas
0	Courses, lower staysails, trysails.
1	Courses, lower staysails, trysails, awnings.
2	Courses, topsails, lower staysails, trysails, spankers, awnings.
3	Courses, topsails, spankers, jibs, lower and topmast staysails.
4	Topsails, topgallant sails, spankers, jibs, topmast staysails.
5	Topsails, lower and topmast studding sails, spankers, jibs, upper staysails, gaff topsails.
6	Topgallant sails, studding sails, jibs, flying jibs, upper staysails, gaff topsails, cutters' and schooners' crossjack sails and square topsails, sails of boats.
7	Topgallant sails, studding sails, flying jibs, royal staysails, cutters' and schooners' topsails, sails of boats.
8	Royals, skysails, topgallant and royal studding sails, cutters' and schooners' topgallant sails, sails of boats.

Note.—For the weight of the several numbers of canvas see p. 433.

Weight of Ships' Rigging and Blocks.

Weight of a ship's running rigging = weight of wire standing rigging × . . . . . . { sailing ships . 1·534; barques . 1·632; brigs . . 1·719 }

Weight of a ship's blocks = weight of running rigging × . . . . { sailing ships . ·369; barques . ·302; brigs . . ·254 }

Note.—The above constants must only be taken as rough approximations.

Proportions of Trestle and Cross Trees in Ships' Tops.

Length of trestle-trees	= hounded length of topmast	× ·22
Breadth of ditto	= length	× ·11
Depth of ditto	= breadth	× ·67
Length of cross-trees	= hounded length of topmast	× ·31
Breadth of ditto	= breadth of trestle-trees .	× 1·0
Depth of ditto	= breadth	× ·67
Length of lubber's hole	= length of trestle-trees .	× ·41
Length of fid	= diameter of lower mast .	× 1·50

	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	40 0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Head	[illegible]		[illegible]		[illegible]		14 0		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
Topmast. Whole length, head included	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Head	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	
Topgallant mast. [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Royal mast	[illegible]		[illegible]		10 0		[illegible]		[illegible]		14 0		14 0		14 0		[illegible]	
Skysail mast							[illegible]		[illegible]		11 0							
Pole	[illegible]		[illegible]		1 0		1 0		1 0		[illegible]		[illegible]		[illegible]		[illegible]	
Lower yard. Whole length, arms included	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17	77 0	19*	77 0	19*	[illegible]	18*	78 0	18	78 0	18	[illegible]	[illegible]
Yard arms, each	4 0		4 0		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	—	[illegible]	
Lower topsail yard. Whole length, arms included	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	67 0	17*	67 0	17*	[illegible]	15	[illegible]	16	[illegible]	16	[illegible]	[illegible]
Yard arms, each	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		1 0		1 0		1 [illegible]	
Upper topsail yard. Whole length, arms included	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	15	[illegible]	[illegible]	67 0	14½	67 0	14½	[illegible]	[illegible]
Yard arms, each	[illegible]		[illegible]		[illegible]		[illegible]		[illegible]		[illegible]	—	[illegible]		[illegible]		1 [illegible]	
Topgallant yard. Whole length, arms included	46 0	11	46 0	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	46 0	12	46 0	12	[illegible]	9
Yard arms, each	2 0		2 0	—	1 0		2 0		2 0		1 [illegible]		[illegible]		[illegible]		1 [illegible]	
Royal yard. Whole length, arms included	32 6	7½	32 6	7½	26 0	6½	37 0	9	37 0	9	[illegible]	6	38 0	10	38 0	10	[illegible] 0	7
Yard arms, each	1 8	—	1 8	—	1 [illegible]		1 6	—	1 [illegible]		1 0		1 0		1 [illegible]		1 [illegible]	
Skysail yard. Whole length, arms included	—	—	—	—	—		20 0	7	20 0	7	[illegible] 0	5						
Yard arms, each	—	—	—	—	—		1 0	—	1 0	—	[illegible]							
Gaff. Whole length, fly included	87 0	10½	87 0	10½	85 0	10½	—	—	—		[illegible]	[illegible]					[illegible]	[illegible]
Spanker boom. Whole length	—	—	—	—	46 0	12½	—	—	—		46 0	15	—	—			45 0	13
Bowsprit, exclusive of housing	85 0	30	—	—	—	—	92 0	30	—		—		21 0	20	—	—	—	—
Jibboom	51 0	12½	—	—	—	—	42 0	17½	—	—	—	—	38 0	15	—	—	—	—
Distance before aft side of stern post †	182 0	—	95 0	—	87 0	—	167 6	—	99 6	—	87 6	—	160 6	—	94 0	—	89 6	—

* Iron. † On load water-line.

Table giving the Dimensions of Masts and Spars of some Screw Steam Vessels as Built by the Thames Ironworks and Shipbuilding Company.

Species of Masts and Spars	H.M.S. 'Warrior,' Ironclad. Length, 380 ft. Breadth, 58 ft. Tonnage, 6,109. Ship-rigged						Spanish Ironclad Frigate 'Victoria.' Length, 316 ft. Breadth, 57 ft. Tonnage, 4,863. Ship-rigged						H.M.S. 'Himalaya,' Troopship. Length, 339 ft. Breadth, 46 ft. Tonnage, 3,505. Ship-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	60 3	38	66 3	40	54 6	26	51 0*	34	54 0	35*	48 0	28½†	53 0	31	56 0	31	50 0	29
Head	19 0	—	20 0	—	13 0	—	18 0	—	18 0	—	12 6	—	14 6	—	14 6	—	11 0	—
Topmast. Whole length, head included	65 0	22	65 0	22	50 6	16	62 6	18½	52 6	18½	39 0	13½	61 0	17	51 0	17	37 0	12
Head	8 9	—	8 9	—	6 9	—	6 4	—	6 6	—	5 0	—	7 6	—	7 6	—	6 0	—
Topgallant mast. From fid hole to hounds	31 6	12½	31 6	12½	23 6	9	26 0	9½	26 0	9½	20 0	6½	23 6	10½	23 6	10½	18 9	7
Royal mast	21 0	—	21 0	—	16 0	—	16 6	—	16 6	—	13 6	—	14 0	—	14 0	—	11 0	—
Pole	4 0	—	4 0	—	3 6	—	6 0	—	6 0	—	4 0	—	2 6	—	2 6	—	1 6	—
Lower yard. Whole length, arms included	105 0	26	105 0	26	71 0	17	90 0	22	90 0	22	67 0	14½	80 0	20	80 0	20	60 0	14½
	4 4	—	4 4	—	3 0	—	4 0	—	4 0	—	6 4	—	4 0	—	4 0	—	6 0	—
included	74 0	16	74 0	16	51 6	11½	67 0	14½	67 0	14½	45 0	9½	64 0	16	64 0	16	44 0	10
	6 2	—	6 2	—	4 3	—	6 4	—	6 4	—	2 9	—	6 0	—	6 0	—	5 6	—
rms included	46 0	11	46 0	11	33 6	8	45 0	9½	45 0	9½	32 0	6	41 0	9½	41 0	9½	30 0	7
	1 11	—	1 11	—	1 5	—	2 9	—	2 9	—	1 3	—	2 6	—	2 6	—	1 3	—
ncluded	32 6	6½	32 6	6½	24 6	5	30 0	6	30 0	6	21 6	4	30 0	6½	30 0	6½	22 0	5
	1 4	—	1 4	—	1 0	—	1 3	—	1 3	—	1 0	—	1 3	—	1 3	—	1 0	—
	—	—	—	—	49 0	11	43 6	9	41 6	8½	44 0	)	33 6	9½	33 6	9½	37 0	9
	—	—	—	—	2 6	—	3 0	—	1 6	—	5 6	—	2 6	—	2 6	—	4 0	—
	—	—	—	—	70 0	16	—	—	—	—	63 0	13½	—	—	—	—	56 0	12
	49 0	40	—	—	—	—	33 6	34	—	—	—	—	33 6	30	—	—	—	—
	49 0	16	—	—	—	—	46 0	16	—	—	—	—	60 0	16	—	—	—	—
	16 6	—	—	—	—	—	16 0	—	—	—	—	—	22 0	—	—	—	—	—
Distance before aft side of stern post ‡	219 0	—	162 0	—	61 6	—	245 6	—	130 8	—	52 0	—	261 9	—	111 9	—	40 0	—

* Of iron, ⅜ to ½ in. thick. † Of iron, 1/16 to ⅜ in. thick. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

Species of Masts and Spars		Merchant Steamer 'Pera,' Length, 303 ft. Breadth, 42 ft. Tonnage, 2,605. Ship-rigged						H.M.S. 'Rover,' Corvette. Length, 280 ft. Brdth., 43 ft. 6 in. Tonnage, 2,556. Ship-rigged						H.M.S. 'Diamond, Corvette. Length, 220 ft. Breadth, 40 ft. Tonnage, 1,969 Ship-rigged					
		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
		Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
		ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast.	From deck to trussel trees	53 0	33	60 6	32	51 0	22	52 6	29*	67 6	31*	46 6	22†	49 6	22	53 0	22	48 0	15
	Head	15 0	—	15 0	—	11 0	—	14 0	—	14 0	—	10 0	—	13 0	—	13 0	—	7 6	—
Topmast.	Whole length, head included	48 0	17	48 0	17	35 6	13	48 6	18	48 6	18	41 0	13½	43 0	13½	43 0	13½	31 0	11
	Head	7 2	—	7 2	—	5 6	—	6 6	—	6 6	—	5 6	—	6 0	—	6 0	—	5 0	—
Topgallant mast.	From fid hole to hounds	23 0	11	23 0	11	19 6	7½	25 0	10	25 0	10	19 6	8	20 0	8½	20 0	8½	16 0	6½
	Royal mast	12 0	—	12 0	—	9 0	—	16 6	—	16 6	—	12 0	—	11 0	—	11 0	—	8 6	—
	Pole	2 6	—	2 6	—	1 6	—	3 6	—	3 6	—	3 0	—	2 6	—	2 6	—	2 0	—
Lower yard.	Whole length, arms included	80 0	17	80 0	17	60 0	13	76 6	19	76 6	19	55 0	13	67 0	16	67 0	16	43 0	10
	Yard arms, each	4 6	—	4 6	—	4 0	—	3 4	—	3 4	—	2 4	—	2 9	—	2 9	—	1 10	—
	included	61 0	13	61 0	13	45 0	10	59 0	13	59 0	13	43 0	9½	49 6	10½	49 6	10½	34 0	8
		5 0	—	5 0	—	4 6	—	4 11	—	4 11	—	3 7	—	4 8	—	4 8	—	3 0	—
	ms included	41 0	8	41 0	8	23 0	5½	40 0	9½	40 0	9½	29 6	7½	32 0	7	32 0	7	22 0	5½
		2 6	—	2 6	—	1 0	—	1 8	—	1 6	—	1 3	—	1 4	—	1 4	—	11	—
	cluded	28 0	6	28 0	6	14 0	3½	29 6	6	29 6	6	23 0	4½	24 0	5	24 0	5	17 0	3½
		1 8	—	1 8	—	1 0	—	1 3	—	1 3	—	1 0	—	1 0	—	1 0	—	8	—
		35 0	9½	35 0	9½	37 6	9½	35 0	9½	35 0	9½	30 0	9½	32 0	8½	32 0	8½	24 0	6
		2 6	—	2 6	—	5 6	—	2 0	—	2 0	—	2 0	—	2 0	—	2 0	—	2 0	—
		—	—	—	—	56 0	13	—	—	—	—	55 6	13	—	—	—	—	—	—
		33 6	30	—	—	—	—	18 0	24	—	—	—	—	19 6	16	—	—	—	—
		67 6	14½	—	—	—	—	51 0	15½	—	—	—	—	39 0	12	—	—	—	—
		33 6	—	—	—	—	—	31 0	—	—	—	—	—	15 0	—	—	—	—	—
Distance before aft side of stern post ‡		242 0	—	186 0	—	53 6	—	232 0	—	132 6	—	45 9	—	176 0	—	91 6	—	35 0	—

* Iron, $\frac{7}{16}$ in. thick. † Iron, ⅜ in. thick. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

Species of Masts and Spars	Turkish Ironclad 'Sultan Mahmoud.' Length, 300 ft. Breadth, 60 ft. Tonnage, 4,277. Barque-rigged						H.M.S. 'Serapis,' Troopship. Length, 360 ft. Breadth, 49 ft. Tonnage, 4,173. Barque-rigged						H.M.S. 'Valiant,' Ironclad. Length, 280 ft. Breadth, 56 ft. Tonnage, 4,063. Barque-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	57 6	36*	63 0	36*	55 0	24†	49 0	30*	54 0	32*	37 0	18†	37 0	36‡	63 0	37‡	55 0	24‡
Head	16 0	—	16 0	—	12 8	—	14 0	—	15 0	—	10 0	—	20 0	—	20 0	—	12 8	—
Topmast. Whole length, head included	—	—	—	—	—	—	46 6	17	46 6	17	—	—	—	—	—	—	—	—
Head	—	—	—	—	—	—	6 3	—	6 3	—	—	—	—	—	—	—	—	—
Topmast. Length to stops	38 6	18	38 6	18	48 0	12	—	—	—	—	44 0	9	48 0	18	48 0	18	48 0	11
Topgallant … ps	22 0	—	22 0	—	—	—	22 6	10½	22 6	10½	—	—	14 0	—	14 0	—	—	—
	—	—	—	—	—	—	14 0	—	14 0	—	—	—	—	—	—	—	—	—
	2 6	—	2 6	—	9 0	—	2 0	—	2 0	—	7 0	—	1 0	—	1 0	—	9 0	—
Lower yard. … s included	91 0	23	91 0	23	—	—	80 8	$18\frac{13}{16}$	80 0	$18\frac{13}{16}$	—	—	91 0	22	91 0	22	—	—
	3 6	—	3 6	—	—	—	3 6	—	3 6	—	—	—	3 10	—	3 10	—	—	—
Topsail yard … ns included	70 0	17½	70 0	17½	—	—	65 0	14½	65 0	14½	—	—	75 0	15	75 0	15	—	—
Gaff topsail …	—	—	—	—	20 0	6	—	—	—	—	21 0	5	67 0‖	—	67 0‖	—	20 0	6
… each	3 10	—	3 10	—	2 0	—	5 0	—	5 0	—	2 0	—	3 6¶	—	3 6¶	—	2 0	—
Topgallant yard. Whole length, arms included	44 0	11	44 0	11	—	—	45 6	9½	45 6	9½	—	—	44 0	10	44 0	10	—	—
Yard arms, each	3 0	—	3 0	—	—	—	2 0	—	2 0	—	—	—	3 0	—	3 0	—	—	—
… included	—	—	—	—	—	—	36 0	7	36 0	7	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	1 6	—	1 6	—	—	—	—	—	—	—	—	—
… l.	36 0	10	40 6	10½	37 0	9	35 6	8½	35 6	8½	35 6	8½	36 0	10	40 6	10½	37 0	8½
	—	—	—	—	56 0	12½	—	—	—	—	53 0	12½	—	—	—	—	56 0	12½
	24 6	28	—	—	—	—	20 6	27	—	—	—	—	28 0	32½	—	—	—	—
…	59 0	16	—	—	—	—	38 0	12	—	—	—	—	48 6	14½	—	—	—	—
Distance before aft side of stern post **	239 6	—	126 3	—	59 9	—	266 9	—	134 9	—	50 6	—	229 0	—	119 3	—	58 9	—

* Of iron, $\frac{5}{16}$ in. thick. † Of iron, ⅜ in. thick. ‡ Of iron. § Of steel, ½ in. thick. ‖ Upper topsail yard.
¶ Arms to lower topsail yard; arms to upper topsail yard = 6 ft. 6 in. each. ** On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (concluded).

Species of Masts and Spars	'Mooltan,' Merchant Steamer. Length, 335 ft. Breadth, 39 ft. Tonnage, 2,[illegible]. Barque-rigged						'Europa,' Merchant Steamer. Length, [illegible] ft. Breadth, 30 ft. 6 in. Tonnage, 1,[illegible]. Barque-rigged						'General Mosellos,' Merchant [illegible] Barque-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	52 0	32	55 0	32	47 0	27	44 0	27	49 0	27	48 0	18	44 0	16	49 0	18	30 0	12
Head	14 6	—	14 6	—	11 0	—	12 0	—	12 0	—	8 0	—	11 0	—	11 0	—	8 0	—
Topmast. Whole length, head included	46 0	17	46 0	17	—	—	36 0	14	36 0	14	—	—	—	—	—	—	—	—
Head	7 0	—	7 0	—	—	—	6 0	—	6 0	—	—	—	—	—	—	—	—	—
Topmast. Length to stops	—	—	—	—	39 0	13	—	—	—	—	47 0	10½	25 3	11	25 3	11	27 6	7½
Topgallant mast. Length to stops	24 0	11	24 0	11	—	—	19 0	7½	19 0	7½	—	—	15 0	—	15 0	—	—	—
Royal mast	15 0	—	15 0	—	—	—	14 6	—	14 6	—	—	—	—	—	—	—	—	—
Pole	6 0	—	6 0	—	11 0	—	4 6	—	4 6	—	4 0	—	7 0	—	7 0	—	8 0	—
Lower yard. Whole length, arms included	75 0	17	75 0	17	—	—	70 0	16½	70 0	16½	—	—	64 0	13	64 0	13	—	—
Yard arms, each	5 0	—	5 0	—	—	—	3 0	—	3 0	—	—	—	3 6	—	3 6	—	—	—
Topsail yard. Whole length, arms included	67 0	12¾	67 0	12¾	—	—	65 0	12½	55 0	12½	—	—	49 0	9½	49 0	9½	—	—
Gaff topsail yard. Whole length	—	—	—	—	*	—	—	—	—	—	*	—	—	—	—	—	16 6	4½
Yard arms, each	6 0	—	6 0	—	—	—	4 0	—	4 0	—	—	—	4 0	—	4 0	—	—	—
Topgallant ya[illegible]cluded	36 0	7½	36 0	7½	—	—	53 0	7½	53 0	7½	—	—	38 6	6½	38 6	6½	—	—
[illegible]	3 0	—	3 0	—	—	—	2 6	—	2 6	—	—	—	2 6	—	2 0	—	—	—
Royal yard. [illegible]	—	—	—	—	—	—	26 0	6	26 0	6	—	—	—	—	—	—	—	—
[illegible]	—	—	—	—	—	—	1 6	—	1 6	—	—	—	—	—	—	—	—	—
Gaff. Whole l[illegible]	38 6	9½	39 6	9½	32 6	9½	33 0	9½	33 0	9½	29 0	8½	31 0	8	31 0	8	30 0	7½
Spanker boom	—	—	—	—	52 0	11	—	—	—	—	42 0	10½	—	—	—	—	41 0	9
Bowsprit, exclusive of housing	33 0	30	—	—	—	—	27 0	26	—	—	—	—	18 9	17	—	—	—	—
Jibboom " "	35 0	14½	—	—	—	—	24 0	14	—	—	—	—	26 0	8	—	—	—	—
Distance before aft side of stern post †	258 0	—	144 6	—	55 3	—	177 0	—	98 0	—	34 0	—	164 0	—	63 6	—	33 0	—

* Jib-headed topsail on mizen mast.

† On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME MERCHANT VESSELS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

Species of Masts and Spars	Sailing Vessel 'Haddington.' Lgth., 200 ft. Brdth., 35 ft. 6 in. Tonnage, 1,223. Barque-rigged						Screw Steamer 'Tanjore.' * Length, 380 ft. Breadth, 38 ft. Tonnage, 3,129				Screw Steamer 'Charkieh.' * Length, 280 ft. Breadth, 30 ft. Tonnage, 1,557				Sailing Vessel 'Mutlah.' * Length, 115 ft. Breadth, 25 ft. Tonnage, 333			
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	52 0	31	56 0	31	52 0	22	50 0	30	58 0	30	46 0	27	51 0	27	43 6	18	51 0	18
Head	15 6	—	15 6	—	11 0	—	14 0	—	14 0	—	12 0		12 0	—	9 6	—	9 6	—
Topmast. Whole length, head included	52 6	17	52 6	17	—	—	47 0	17½	47 0	17½	39 0	14½	39 0	14½	34 3	11½	34 3	11½
Head	7 6	—	7 6	—	—	—	7 0	—	7 0	—	6 0	—	6 0	—	4 9	—	4 9	—
Topmast. Length to stops	—	—	—	—	58 0	18	—	—	—	—	—	—	—	—	—	—	—	—
Topgallant mast. Length to stops	24 6	10½	24 6	10½	—	—	24 0	11½	24 0	11½	21 0	10½	21 0	10½	15 0	6½	16 0	6½
Royal mast	14 6	—	14 6	—	—	—	—	—	—	—	—	—	—	—	8 6	4½	9 6	4½
Pole	2 0	—	2 0	—	12 0	—	16 0	9½	16 0	9½	11 0	8½	11 0	8½	2 0	—	2 0	—
Lower yard. Whole length, arms included	84 0	20	84 0	20	—	—	78 0	17½	78 0	17½	70 0	16	70 0	16	61 9	11½	56 6	12
Yard arms, each	4 0	—	4 0	—	—	—	5 0	—	5 0		4 0	—	4 0	—	2 6	—	2 6	—
Topsail yard. Whole length, arms included	64 0	15	64 0	15	—	—	58 0	14	58 0	14	56 0	13	56 0	13	38 6	6½	38 6	7
Yard arms, each	5 0	—	5 0	—	—	—	5 0	—	5 0	—	5 0	—	5 0	—	2 0	—	2 0	—
Topgallant yard. V cluded	42 0	10	42 0	10	—	—	40 0	9	40 0	9	36 0	8	36 0	8	25 9	5½	26 9	6
Y	2 0	—	2 0	—	—	—	2 0	—	2 0	—	3 0	—	3 0	—	1 0	—	1 0	—
Royal yard. Whole length, arms included	30 0	7	30 0	7	—	—	—	—	—	—	—	—	—	—	19 6	4½	19 9	4½
Yard arms, each	1 8	—	1 8	—	—	—	—	—	—	—	—	—	—	—	1 0	—	1 0	—
Gaff. Whole length	35 6	11	35 6	11	52 0	10½	40 0	9½	40 0	9½	36 6	8	36 6	8	—	—	36 6	6½
Fly	2 6	—	2 6	—	4 0	—	5 0	—	5 0	—	5 0		5 0	—	—	—	1 6	—
Spanker boom	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	†55 6	11½
Bowsprit, exclusive of housing	36 0	30	—	—	—	—	43 0	26	—		36 0	22	—	—	24 6	18	—	—
Jibboom " "	34 0	14	—	—	—	—	—	—	—	—	—	—	—	—	35 0	10	—	—
Distance before aft side of stern post ‡	175 6	—	84 6	—	85 0	—	212	—	88 3	—	191 6	—	71 6	—	87 0	—	89 9	—

* Brig-rigged. † Main boom. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAMERS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

Species of Masts and Spars	'Vasco de Gama,' Portuguese Ironclad. Length, 300 ft. Breadth, 40 ft. Tonnage, 1,487. 3-masted Schooner					
	Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	*45 0	22	*49 0	22	41 0	16
Head	10 0	—	10 0	—	7 0	—
Topmast. Length to stops	27 0	12	33 6	11	21 0	8
Topgallant mast	18 6	—	—	—	—	—
Royal mast	—	—	—	—	—	—
Pole	2 6	—	6 6	—	5 0	—
Lower yard. Whole length	60 0	14	—	—	—	—
Yard arms, each	3 0	—	—	—	—	—
Topsail yard. Whole length	41 0	10	—	—	—	—
Gaff topsail yard. Whole length	—	—	20 0	6	14 0	4½
Yard arms, each	3 0	—	2 6	—	1 6	—
Topgallant yard. Whole length	28 0	7	—	—	—	—
Yard arms, each	1 9	—	—	—	—	—
Royal yard. Whole length	—	—	—	—	—	—
Yard arms, each	—	—	—	—	—	—
Gaff. Whole length, fly included	29 0	8½	29 0	8½	24 0	6½
Fly	2 0	—	2 0	—	1 6	—
Boom. Whole length	—	—	—	—	24 0	8
Bowsprit, exclusive of housing	16 0	17	—	—	—	—
Jibboom " "	41 0	11	—	—	—	—
Distance before rudder post ‡	141 0	—	66 0	—	23 0	—

Species of Masts and Spars	'Alexandria,' [illegible], 30 ft. Tonnage, [illegible]. 3-masted Schooner					
	Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	44 0	19½	47 0	18½	37 6	15
Head	10 0	—	10 0	—	6 6	-
Topmast. Length to stops	25 6	10	41 0	9½	25 0	8
Topgallant mast	16 0	—	—	—	—	—
Royal mast	—	—	—	—	—	—
Pole	5 0	—	6 0	—	5 0	—
Lower yard. Whole length	65 0	14½	—	—	—	—
Yard arms, each	4 0	—	—	—	—	—
Topsail yard. Whole length	49 0	10	—	—	—	—
Gaff topsail yard. Whole length	—	—	19 0	6	16 6	5
Yard arms, each	4 6	—	2 0	—	1 6	—
Topgallant yard. Whole length	33 6	7½	—	—	—	—
Yard arms, each	2 6	—	—	—	—	—
Royal yard. Whole length	—	—	—	—	—	—
Yard arms, each	—	—	—	—	—	—
Gaff. Whole length, fly included	31 0	8	35 0	8½	27 0	6½
Fly	2 0	—	2 0	—	1 6	—
Boom. Whole length	42 0	10	47 0	10½	36 6	9
Bowsprit, exclusive of housing	22 0	18	—	—	—	—
Jibboom " "	23 0	18	—	—	—	-
Distance before rudder post ‡	161 0	—	91 0	—	29 6	—

Species of Masts and Spars	H.M.S. 'Swift,' [illegible], 30 ft. [illegible] 3-masted Schooner					
	Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	38 9	16½	41 3	16½	37 6	11
Head	7 3	—	7 6	—	7 0	—
Topmast. Length to stops	19 6	8½	21 6	8½	24 6	5½
Topgallant mast	10 0	-	—	—	—	—
Royal mast	—	—	—	—	—	—
Pole	4 0	—	4 0	—	5 0	—
Lower yard. Whole length	45 0	10½	—	—	—	—
Yard arms, each	2 0	—	—	—	—	—
Topsail yard. Whole length	33 6	7	—	—	—	—
Gaff topsail yard. Whole length	—	—	†	—	†	—
Yard arms, each	3 0	—	—	—	—	—
Topgallant yard. Whole length	20 0	4½	—	—	—	—
Yard arms, each	1 9	—	—	—	—	—
Royal yard. Whole length	—	—	—	—	—	—
Yard arms, each	—	—	—	—	—	—
Gaff. Whole length, fly included	23 0	7½	22 0	7½	14 0	5½
Fly	1 0	—	—	—	—	—
Boom. Whole length	—	—	—	—	26 0	9
Bowsprit, exclusive of housing	16 0	13	—	—	—	—
Jibboom " "	15 0	7½	—	—	—	—
Distance before rudder post ‡	134 0	—	64 6	—	17 3	—

* Of iron. † Jib-headed topsail. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCHOONER-RIGGED SCREW STEAMERS.

Species of Masts and Spars	Length, 150 ft. Breadth, 36 ft. Tonnage, 483. Schooner-rigged *				Length, 130 ft. Breadth, 20 ft. Tonnage, 251. Schooner-rigged				Length, 108 ft. Breadth, 17 ft. 6 in. Tonnage, 159. Schooner-rigged				Length, 76 ft. Breadth, 15 ft. Tonnage, 89. Fore and Aft Schooner			
	Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to hounds	42 6	15	44 0	14½	39 0	15	41 0	14	37 0	14	38 0	13	26 3	12	28 6	11
Head	10 0	—	10 0	—	8 0	—	8 0	—	7 6	—	7 6	—	—	—	—	—
Topmast. Length to stops	21 0	10	36 6	9	16 0	7	28 0	7	26 0	9½	27 0	9	20 0	—	20 0	—
Pole	—	—	3 6	—	—	—	4 0	—	3 0	—	3 0	—	3 0	—	4 0	—
Topgallant mast. Length to stops	12 6	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Pole	3 0	—	—	—	4 0	—	—	—	—	—	—	—	—	—	—	—
Lower yard. Whole length	60 0	10½	—	—	46 0	8	—	—	41 0	9½	—	—	—	—	—	—
Yard arms, each	3 0	—	—	—	2 0	—	—	—	2 6	—	—	—	—	—	—	—
Topsail yard. Whole length	44 6	8	—	—	34 0	7	—	—	24 0	8	—	—	—	—	—	—
Gaff topsail yard. Whole length	—	—	14 0	5	—	—	18 0	6	—	—	19 0	11	11 0	4	13 0	4½
Yard arms, each	4 0	—	2 0	—	2 6	—	1 6	—	2 0	—	2 0	—	1 0	—	1 6	—
Topgallant yard. Whole length	29 0	5¾	—	—	21 0	5	—	—	—	—	—	—	—	—	—	—
Yard arms, each	2 0	—	—	—	1 6	—	—	—	—	—	—	—	—	—	—	—
Gaff. Whole length, fly included	31 0	6¼	34 0	6½	19 0	6	27 0	7	25 0	7½	26 6	7½	17 0	5½	18 6	5½
Fly	2 0	—	2 0	—	2 0	—	2 0	—	2 6	—	3 0	—	1 3	—	2 0	—
Spanker boom	—	—	53 0	11	—	—	45 0	10	—	—	28 0	7	—	—	28 0	7
Bowsprit, exclusive of housing	28 0	10½	—	—	18 0	12	—	—	21 0	11	—	—	14 6	9	—	—
Jibboom " "	—	—	—	—	15 0	5	—	—	—	—	—	—	—	—	—	—
Housing	—	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Distance before rudder post †	114 0	—	45 6	—	92 6	—	41 0	—	81 6	—	34 3	—	57 0	—	24 0	—

* Sloop of war. † On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME WELL-KNOWN CLIPPER SHI

Species of Masts and Spars	Length, 230 ft. Breadth, 37 ft. Tonnage, 1,538						Length, 215 ft. Breadth, 36 ft. Tonnage, 1,333						Length, 208 ft. Breadth, [illegible] ft. Tonnage, 1,129					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	50 6	36	53 0	36	45 6	23	46 0	32*	60 6	33*	46 0	28*	43 0	30	47 8	31	42 9	28
Head	15 6	—	15 6	—	12 0	—	14 3	—	14 3		11 0	—	12 0	—	12 0	—	10 6	—
Topmast. Whole length, head included	53 0	19	53 0	19	38 0	14	48 0	18	48 0	18	40 0	15	44 6	15	44 6	15	36 6	14
Head	9 0	—	9 0	—	6 6	—	7 6	—	7 6	—	6 6	—	7 9	—	7 9	—	7 0	—
Topgallant mast. From fid hole to hounds	24 0	12	24 0	12	18 6	8½	34 6	13	34 6	13	28 6	10½	21 6	12	21 6	12	17 0	10
Royal mast	15 0	—	15 0	—	10 6	—	18 0	—	18 0	—	14 0	—	14 6	—	14 6	—	11 0	—
Skysail mast	—	—	—	—	—	—	13 0	—	13 0	—	11 0	—	—	—	—	—	—	—
Pole	2 0	—	2 0	—	1 6	—	1 0	—	1 0	—	1 0	—	5 6	—	5 6	—	5 0	—
Lower yard. Whole length, arms included	85 0	23	85 0	22	66 0	17	77 0	19*	77 0	19*	66 0	18*	73 6	18	73 6	18	56 0	14
Yard arms, each	4 0	—	4 0	—	5 0	—	2 9	—	2 9	—	2 6	—	2 9	—	2 9	—	2 3	—
Lower topsail yard. Whole length, arms included	69 0	18	69 0	18	52 0	13	67 6	17*	67 6	17*	56 0	15	62 0	16	62 0	16	47 9	12
Yard arms, each	2 6	—	2 6	—	2 0	—	3 6	—	3 6	—	3 0	—	1 6	—	1 6	—	1 3	—
Upper topsail yard. Whole length, arms included	65 0	16½	65 0	16½	50 0	12½	63 0	15	63 0	15	50 0	13	57 0	14½	57 0	14½	45 9	13
Yard arms, each	5 6	—	5 6	—	3 0	—	2 0	—	2 0	—	2 0	—	3 0	—	3 0	—	1 9	—
nded	46 0	11	46 0	11	33 0	8½	50 6	13	50 6	13	38 6	9	46 6	12	46 6	12	36 0	9
	2 0	—	2 0	—	1 9	—	2 0	—	2 0	—	1 6	—	2 3	—	2 3	—	1 3	—
	32 6	7½	32 6	7½	28 0	6½	37 6	9	37 6	9	28 6	6	33 0	10	33 0	10	28 0	7
	1 3	—	1 3	—	1 2	—	1 6	—	1 6	—	1 0	—	1 9	—	1 9	—	1 3	—
	—	—	—	—	—	—	29 0	7	29 0	7	30 0	5	—	—	—	—	—	—
	—	—	—	—	—	—	1 0	—	1 0	—	0 9	—	—	—	—	—	—	—
	37 0	10½	37 0	10½	35 0	10½	—	—	—	—	36 6	9	—	—	—	—	30 6	9
	—	—	—	—	48 6	12½	—	—	—	—	46 6	15	—	—	—	—	45 0	13
	35 0	30	—	—	—	—	22 0	30	—	—	—	—	21 6	20	—	—	—	—
	51 0	12½	—	—	—	—	42 0	17½	—	—	—	—	38 0	15	—	—	—	—
	182 0	—	95 0	—	87 0	—	157 6	—	99 6	—	87 6	—	160 6	—	94 0	—	89 6	—

* Iron. † On load water-line.

[illegible] MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

H. M. S. 'W[illegible]' — Ship-rigged

Species of Masts and Spars	Fore Mast Lgth.	Fore Mast Dia.	Main Mast Lgth.	Main Mast Dia.	Mizen Mast Lgth.	Mizen Mast Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	60 3	38	66 3	40	54 6	26
Head	18 0	—	20 0	—	13 0	—
Topmast. Whole length, head included	65 0	22	65 0	22	40 6	16
Head	8 9	—	8 9	—	6 9	—
Topgallant mast. From fid hole to hounds	31 6	12½	31 6	12½	23 6	9
Royal mast	21 0	—	21 0	—	16 0	—
Pole	4 0	—	4 0	—	3 6	—
Lower yard. Whole length, arms included	105 0	26	105 0	25	71 0	17
Yard arms, each	4 4	—	4 4	—	3 0	—
[illegible]ed	74 0	16	74 0	16	51 6	11½
	6 9	—	6 2	—	4 3	—
[illegible]luded	46 0	11	46 0	11	33 6	8
	1 11	—	1 11	—	1 5	—
[illegible]l.	33 6	6¼	33 6	6¼	24 6	5
	1 4	—	1 4	—	1 0	—
	—	—	—	—	49 0	11
	—	—	—	—	2 6	—
	—	—	—	—	70 0	16
	49 0	40	—	—	—	—
	49 0	16	—	—	—	—
	16 6	—	—	—	—	—
	219 0	—	162 0	—	61 6	—

Spanish Ironclad Frigate 'Victoria.' Length, 316 ft. Breadth, 57 ft. Tonnage, 4,983. Ship-rigged

Species of Masts and Spars	Fore Mast Lgth.	Fore Mast Dia.	Main Mast Lgth.	Main Mast Dia.	Mizen Mast Lgth.	Mizen Mast Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	51 0*	24	54 0	35*	48 0	28¼†
Head	18 0	—	18 0	—	12 6	—
Topmast. Whole length, head included	52 6	18¼	52 6	18¼	39 0	13¾
Head	6 4	—	6 6	—	5 0	—
Topgallant mast. From fid hole to hounds	26 0	9¼	26 0	9¼	20 0	6¼
Royal mast	16 6	—	16 6	—	13 6	—
Pole	6 0	—	6 0	—	4 0	—
Lower yard. Whole length, arms included	90 0	22	90 0	22	67 0	14¼
Yard arms, each	4 0	—	4 0	—	6 4	—
[illegible]ed	67 0	14¼	67 0	14¼	46 0	9¼
	6 4	—	6 4	—	2 9	—
[illegible]luded	45 0	9¼	45 0	9¼	32 0	6
	2 9	—	2 9	—	1 8	—
[illegible]l.	30 0	6	30 0	6	21 6	4
	1 8	—	1 8	—	1 0	—
	43 6	9	41 6	8¾	44 0	[illegible]
	3 0	—	1 6	—	6 6	—
	—	—	—	—	63 0	13¼
	31 6	34	—	—	—	—
	46 0	16	—	—	—	—
	10 0	—	—	—	—	—
	245 6	—	186 6	—	52 0	—

H. M. S. 'Himalaya,' Troopship. Length, 330 ft. Breadth, 46 ft. Tonnage, 3,550. Ship-rigged

Species of Masts and Spars	Fore Mast Lgth.	Fore Mast Dia.	Main Mast Lgth.	Main Mast Dia.	Mizen Mast Lgth.	Mizen Mast Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	58 0	31	56 0	31	50 0	22
Head	14 6	—	14 6	—	11 0	—
Topmast. Whole length, head included	51 0	17	51 0	17	37 0	12
Head	7 6	—	7 6	—	5 0	—
Topgallant mast. From fid hole to hounds	28 6	10½	28 6	10½	18 9	7
Royal mast	14 0	—	14 0	—	11 0	—
Pole	2 6	—	2 6	—	1 6	—
Lower yard. Whole length, arms included	80 0	20	80 0	20	60 0	14½
Yard arms, each	4 0	—	4 0	—	6 0	—
[illegible]ed	64 0	16	64 0	16	44 0	10
	5 0	—	5 0	—	3 6	—
[illegible]luded	41 0	9¼	41 0	9¼	30 0	7
	2 6	—	2 6	—	1 8	—
[illegible]l.	30 0	6¼	30 0	6¼	22 0	5
	1 3	—	1 3	—	1 0	—
	33 6	9¼	33 6	9¼	37 0	9
	2 6	—	2 6	—	4 0	—
	—	—	—	—	56 0	12
	33 6	30	—	—	—	—
	60 0	16	—	—	—	—
	32 0	—	—	—	—	—
	261 9	—	111 9	—	40 0	—

* Of iron, ⅝ to ½ in. thick. † Of iron, 11/16 to ⅝ in. thick. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME WELL-KNOWN CLIPPER SHI[illegible]

Length, 280 ft. Breadth, 37 ft. Tonnage, 1,386

Species of Masts and Spars	Fore Mast Length ft. in.	Fore Mast Dia. in.	Main Mast Length ft. in.	Main Mast Dia. in.	Mizen Mast Length ft. in.	Mizen Mast Dia. in.
Lower mast. From deck to trussel trees	60 6	36	58 0	36	45 6	23
Head	15 6	—	15 6	—	12 0	—
Topmast. Whole length, head included	58 0	19	58 0	19	38 0	14
Head	9 0	—	9 0	—	6 6	—
Topgallant mast. From fid hole to hounds	24 0	12	24 0	12	18 6	8½
Royal mast	15 0	—	15 0	—	10 6	—
Skysail mast	—	—	—	—	—	—
Pole	2 0	—	2 0	—	1 6	—
Lower yard. Whole length, arms included	85 0	22	85 0	22	66 0	17
Yard arms, each	4 0	—	4 0	—	5 0	—
Lower topsail yard. Whole length, arms included	69 0	18	69 0	18	52 0	13
Yard arms, each	2 6	—	2 6	—	2 0	—
Upper topsail yard. … ns included	65 0	16½	65 0	16½	50 0	12½
	5 6	—	5 6	—	3 0	—
Topgallant yard. W… included	46 0	11	46 0	11	38 0	8½
Yard arms, each	2 0	—	2 0	—	1 9	—
Royal yard. Whole length, arms included	32 6	7½	32 6	7½	28 0	6½
Yard arms, each	1 8	—	1 8	—	1 2	—
… s included	—	—	—	—	—	—
	—	—	—	—	—	—
	57 0	10½	57 0	10½	35 0	10½
	—	—	—	—	46 6	12½
	36 0	20	—	—	—	—
	51 0	19½	—	—	—	—
… ost †	182 0	—	95 0	—	87 0	—

Length, 215 ft. Breadth, 36 ft. Tonnage, 1,333

Species of Masts and Spars	Fore Mast Length ft. in.	Fore Mast Dia. in.	Main Mast Length ft. in.	Main Mast Dia. in.	Mizen Mast Length ft. in.	Mizen Mast Dia. in.
Lower mast. From deck to trussel trees	46 0	32*	60 6	33*	46 0	23*
Head	14 3	—	14 3	—	11 0	—
Topmast. Whole length, head included	48 0	18	48 0	18	40 0	15
Head	7 6	—	7 6	—	6 6	—
Topgallant mast. From fid hole to hounds	34 6	13	34 6	13	28 6	10½
Royal mast	18 0	—	18 0	—	14 0	—
Skysail mast	13 0	—	13 0	—	11 0	—
Pole	1 0	—	1 0	—	1 0	—
Lower yard. Whole length, arms included	77 0	19*	77 0	19*	66 0	18*
Yard arms, each	2 9	—	2 9	—	3 6	—
Lower topsail yard. Whole length, arms included	67 6	17*	67 6	17*	56 0	15
Yard arms, each	3 6	—	3 6	—	3 0	—
Upper topsail yard. … ns included	68 0	15	68 0	15	50 0	13
	2 0	—	2 0	—	2 0	—
Topgallant yard. W… included	60 6	13	60 6	13	38 6	9
Yard arms, each	2 0	—	2 0	—	1 6	—
Royal yard. Whole length, arms included	37 6	9	37 6	9	28 6	6
Yard arms, each	1 6	—	1 6	—	1 0	—
… s included	29 0	7	29 0	7	20 0	5
	1 0	—	1 0	—	0 9	—
	—	—	—	—	36 6	9
	—	—	—	—	46 6	15
	39 0	30	—	—	—	—
	42 0	17½	—	—	—	—
… ost †	167 6	—	99 6	—	87 6	—

Length, 208 ft. Breadth, 34 ft. Tonnage, 1,119

Species of Masts and Spars	Fore Mast Length ft. in.	Fore Mast Dia. in.	Main Mast Length ft. in.	Main Mast Dia. in.	Mizen Mast Length ft. in.	Mizen Mast Dia. in.
Lower mast. From deck to trussel trees	48 0	30	47 3	31	42 9	26
Head	12 0	—	12 0	—	10 6	—
Topmast. Whole length, head included	44 6	15	44 6	15	36 6	14
Head	7 9	—	7 9	—	7 0	—
Topgallant mast. From fid hole to hounds	21 6	12	21 6	12	17 0	10
Royal mast	14 6	—	14 6	—	11 0	—
Skysail mast	—	—	—	—	—	—
Pole	5 6	—	5 6	—	5 0	—
Lower yard. Whole length, arms included	73 6	16	73 6	16	68 0	14
Yard arms, each	2 9	—	2 9	—	2 3	—
Lower topsail yard. Whole length, arms included	63 0	16	62 0	16	47 9	12
Yard arms, each	1 6	—	1 6	—	1 3	—
Upper topsail yard. … ns included	57 0	14½	57 0	14½	45 9	12
	3 0	—	3 0	—	1 9	—
Topgallant yard. W… included	46 6	12	46 6	12	36 0	9
Yard arms, each	2 3	—	2 3	—	1 8	—
Royal yard. Whole length, arms included	38 0	10	38 0	10	28 0	7
Yard arms, each	1 9	—	1 9	—	1 3	—
… s included	—	—	—	—	—	—
	—	—	—	—	—	—
	—	—	—	—	30 6	9
	—	—	—	—	45 0	18
	21 6	29	—	—	—	—
	38 0	16	—	—	—	—
… ost †	160 6	—	94 0	—	89 6	—

* Iron. † On load water-line.

... OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

Species of Masts and Spars	H.M.S. '...' Ship-rigged						Spanish Ironclad Frigate 'Victoria.' Length, 316 ft. Breadth, 57 ft. Tonnage, 4,353. Ship-rigged						H.M.S. 'Himalaya,' Troopship. Length, 339 ft. Breadth, 46 ft. Tonnage, 3,500. Ship-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	60 3	38	66 3	40	64 6	26	51 0*	34	64 0	35*	48 0	28½†‡	58 0	31	56 0	31	50 0	22
Head	19 0	—	20 0	—	13 0	—	18 0	—	18 0	—	12 6	—	14 6	—	14 6	—	11 0	—
Topmast. Whole length, head included	65 0	22	65 0	22	50 6	16	52 6	18½	52 6	18½	39 0	12½	51 0	17	51 0	17	37 0	12
Head	8 9	—	8 9	—	6 9	—	6 6	—	6 6	—	5 0	—	7 6	—	7 6	—	5 0	—
Topgallant mast. From fid hole to hounds	31 6	12½	31 6	12½	23 6	9	26 0	9½	26 0	9½	20 0	6¾	22 6	10½	22 6	10½	18 9	7
Royal mast	21 0	—	21 0	—	16 0	—	16 6	—	16 6	—	13 6	—	14 0	—	14 0	—	11 0	—
	4 0	—	4 0	—	3 6	—	6 0	—	6 0	—	4 0	—	2 6	—	2 6	—	1 6	—
...l	105 0	25	105 0	25	71 0	17	90 0	22	90 0	22	67 0	14½	80 0	20	80 0	20	60 0	14½
	4 4	—	4 4	—	3 0	—	4 0	—	4 0	—	6 4	—	4 0	—	4 0	—	6 0	—
...ed	74 0	16	74 0	16	61 6	11½	67 0	14½	67 0	14½	45 0	9½	64 0	15	64 0	15	44 0	10
	6 2	—	6 2	—	4 3	—	6 4	—	6 4	—	2 9	—	5 0	—	5 0	—	3 6	—
...luded	46 0	11	46 0	11	33 6	8	45 0	9½	45 0	9½	32 0	6	41 0	9½	41 0	9½	30 0	7
	1 11	—	1 11	—	1 5	—	2 9	—	2 9	—	1 3	—	2 6	—	2 6	—	1 3	—
...l.	32 6	6½	32 6	6½	24 6	5	30 0	6	30 0	6	21 6	4	30 0	6½	30 0	6½	22 0	5
	1 4	—	1 4	—	1 0	—	1 3	—	1 3	—	1 0	—	1 3	—	1 3	—	1 0	—
	—	—	—	—	49 0	11	43 6	9	41 6	8¾	44 0	[illegible]	33 6	9½	33 6	9½	37 0	9
	—	—	—	—	2 6	—	3 0	—	1 6	—	5 6	—	2 6	—	2 6	—	4 0	—
	—	—	—	—	70 0	16	—	—	—	—	68 0	12½	—	—	—	—	54 0	12
	49 0	40	—	—	—	—	32 6	24	—	—	—	—	33 6	20	—	—	—	—
	49 0	16	—	—	—	—	46 0	16	—	—	—	—	60 0	15	—	—	—	—
	16 6	—	—	—	—	—	16 0	—	—	—	—	—	32 0	—	—	—	—	—
	219 0	—	162 0	—	61 6	—	245 6	—	136 6	—	52 0	—	261 9	·	111 9	—	40 0	—

* Of iron, ⅝ to ½ in. thick. † Of iron, 11/16 to ⅝ in. thick. ‡ On load water-line.

Table giving the Dimensions of Masts and Spars of some well-known Clipper Ships.

Species of Masts and Spars	Length, 230 ft. Breadth, 37 ft. Tonnage, 1,528						Length, 215 ft. Breadth, 36 ft. Tonnage, 1,333						Length, 208 ft. Breadth, 34 ft. Tonnage, 1,159					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in	ft. in.	in	ft. in.	in.	ft. in.	in	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	50 6	36	58 0	36	45 6	29	46 0	32*	60 6	32*	46 0	28*	48 0	30	47 3	31	42 9	28
Head	15 6	—	15 6	—	19 0	—	14 3	—	14 3	—	11 0	—	12 0	—	12 0	—	10 6	—
Topmast. Whole length, head included	58 0	19	58 0	19	38 0	14	48 0	18	48 0	18	40 0	16	44 6	15	44 6	15	36 6	14
Head	9 0	—	9 0	—	6 6	—	7 6	—	7 6	—	6 6	—	7 9	—	7 9	—	7 0	—
Topgallant mast. From fid hole to hounds	24 0	12	24 0	12	18 6	8½	34 6	13	34 6	13	28 6	10½	21 6	12	21 6	12	17 0	10
Royal mast	15 0	—	15 0	—	10 6	—	18 0	—	18 0	—	14 0	—	14 6	—	14 6	—	11 0	—
Skysail mast	—	—	—	—	—	—	18 0	—	18 0	—	11 0	—	—	—	—	—	—	—
Pole	2 0	—	2 0	—	1 6	—	1 0	—	1 0	—	1 0	—	5 6	—	5 6	—	5 0	—
Lower yard. Whole length, arms included	85 0	22	85 0	22	66 0	17	77 0	19*	77 0	19*	66 0	18*	73 6	18	73 6	18	58 0	14
Yard arms, each	4 0	—	4 0	—	5 0	—	2 9	—	2 9	—	2 6	—	2 9	—	2 9	—	2 3	—
Lower topsail yard. Whole length, arms included	69 0	18	69 0	18	52 0	13	67 6	17*	67 6	17*	56 0	15	63 0	16	63 0	16	47 9	12
Yard arms, each	2 6	—	2 6	—	2 0	—	3 6	—	3 6	—	3 0	—	1 6	—	1 6	—	1 3	—
Upper topsail yard. Whole length, arms included	65 0	16½	65 0	16½	50 0	12½	63 0	15	63 0	15	50 0	13	57 0	14½	57 0	14½	45 9	12
Yard arms, each	5 6	—	5 6	—	3 0	—	2 0	—	2 0	—	2 0	—	3 0	—	3 0	—	1 9	—
Topgallant yard. Whole length, arms included	46 0	11	46 0	11	38 0	8½	50 6	13	50 6	13	38 6	9	46 6	12	46 6	12	36 0	9
Yard arms, each	2 0	—	2 0	—	1 9	—	2 0	—	2 0	—	1 6	—	2 3	—	2 3	—	1 3	—
included	32 6	7½	32 6	7½	28 0	6½	37 6	9	37 6	9	28 6	6	38 0	10	38 0	10	28 0	7
	1 3	—	1 3	—	1 2	—	1 6	—	1 6	—	1 0	—	1 9	—	1 9	—	1 3	—
s included	—	—	—	—	—	—	29 0	7	29 0	7	20 0	5	—	—	—	—	—	—
	—	—	—	—	—	—	1 0	—	1 0	—	0 9	—	—	—	—	—	—	—
†	37 0	10½	37 0	10½	35 0	10½	—	—	—	—	36 6	9	—	—	—	—	30 6	9
	—	—	—	—	46 6	12½	—	—	—	—	46 6	16	—	—	—	—	45 0	13
Bowsprit, outside of housing	86 0	30	—	—	—	—	39 0	30	—	—	—	—	31 6	29	—	—	—	—
Jibboom " "	51 0	12½	—	—	—	—	42 0	17½	—	—	—	—	38 0	15	—	—	—	—
Distance before aft side of stern post †	188 0	—	95 0	—	37 0	—	167 6	—	99 6	—	37 6	—	160 6	—	94 0	—	39 6	—

* Iron. † On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

SPECIES OF MASTS AND SPARS	H.M.S. 'Warrior,' Ironclad. Length, 380 ft. Breadth, 58 ft. Tonnage, 6,039. Ship-rigged						Spanish Ironclad Frigate 'Victoria.' Length, 316 ft. Breadth, 57 ft. Tonnage, 4,863. Ship-rigged						H.M.S. 'Himalaya,' Troopship. Length, 339 ft. Breadth, 46 ft. Tonnage, 3,505. Ship-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in	in	ft. in.	in.	ft. in.	in	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	60 8	38	66 8	40	54 6	26	51 0*	34	54 0	36*	48 0	23½†	53 0	31	56 0	31	50 0	22
Head	19 0	—	20 0	—	13 0	—	18 0	—	18 0	—	12 6	-	14 6	—	14 6	—	11 0	—
Topmast. Whole length, head included	65 0	22	65 0	22	50 6	16	52 6	18¾	52 6	18¼	39 0	12¾	51 0	17	51 0	17	37 0	12
Head	8 0	—	8 9	—	6 9	—	6 6	—	6 6	—	5 0	—	7 6	—	7 6	—	5 0	—
Topgallant mast. From fid hole to hounds	31 6	12½	31 6	12½	23 6	9	26 0	9½	26 0	9½	20 0	6¾	23 6	10½	23 6	10½	18 9	7
Royal mast	21 0	—	21 0	—	16 0	—	16 6	—	16 6	—	13 6	—	14 0	—	14 0	—	11 0	—
Pole	4 0	—	4 0	—	3 6	—	6 0	—	6 0	—	4 0		3 6	—	3 6	—	1 6	—
Lower yard. Whole length, arms included	105 0	25	105 0	25	71 0	17	90 0	22	90 0	22	67 0	14½	80 0	20	80 0	20	60 0	14½
Yard arms, each	4 4	—	4 4	—	3 0	—	4 0	—	4 0	—	6 4	—	4 0	—	4 0	—	6 0	—
Topsail yard. Whole length, arms included	74 0	16	74 0	16	51 6	11½	67 0	14½	67 0	14½	46 0	9½	64 0	15	64 0	15	44 0	10
	6 2	—	6 2	—	4 8	—	6 4	—	6 4	—	2 9		5 0	—	5 0	—	3 6	—
Topgallant ; [illegible] luded	46 0	11	46 0	11	33 6	8	45 0	9½	45 0	9½	39 0	6	41 0	9½	41 0	9½	30 0	7
	1 11	—	1 11	—	1 6	—	2 9	—	2 9	—	1 3	—	2 6	—	2 6	—	1 8	—
Royal yard. [illegible]	32 6	6½	32 6	6½	24 6	5	30 0	6	30 0	6	21 6	4	30 0	6½	30 0	6½	22 0	5
	1 4	—	1 4	—	1 0	—	1 3	—	1 3	—	1 0	—	1 3	—	1 3	—	1 0	—
Gaff. Whole length, fly included	—	—	—	—	49 0	11	43 6	9	41 6	8¾	44 0	)	33 6	9½	33 6	9½	37 0	9
Fly	—	—	—	—	2 6		3 0	—	1 6	—	5 6	—	2 6	—	2 6	—	4 0	—
Spanker boom. Whole length	—	—	—	—	70 0	16	—	—	—	—	63 0	13½	—	—	—	—	56 0	12
Bowsprit, exclusive of housing	49 0	40	—	—	—	—	39 6	34	—	—	—		38 6	30	—	—	—	—
Jibboom, housing included	49 0	16	—	—	—	—	46 0	16	—	—	—	—	60 0	15	—	—	—	—
Housing	16 6	—	—	—	—	—	16 0	—	—	—	—	—	32 0	—	—	—	—	—
Distance before aft side of stern post ‡	219 0	—	162 0	—	61 6	—	245 6	—	136 6	—	52 0	—	261 9	—	111 9	—	40 0	—

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

Species of Masts and Spars	Merchant Steamer 'Pera,' [illegible] ft. [illegible] Ship-rigged						H.M.S. 'Rover,' Corvette. Length, 280 ft. Brdth., 43 ft. 6 in. Tonnage, 2,556. Ship-rigged						H.M.S. 'Diamond,' Corvette. Length, 220 ft. Breadth, 40 ft. Tonnage, 1,883. Ship-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	58 0	32	60 6	32	51 0	22	52 6	29*	57 6	31*	45 6	22†	49 6	22	58 0	22	43 0	15
Head	15 0	—	15 0	—	11 0	—	14 0	—	14 0	—	10 0	—	18 0	—	18 0	—	7 6	—
Topmast. Whole length, head included	48 0	17	48 0	17	35 6	13	48 6	18	48 6	18	41 0	13½	43 0	13½	43 0	13½	31 0	11
Head	7 2	—	7 2	—	5 6	—	6 6	—	6 6	—	5 6	—	6 0	—	6 0	—	5 0	—
Topgallant mast. From fid hole to hounds	23 0	11	23 0	11	19 6	7½	25 0	10	25 0	10	19 6	6	20 0	8½	20 0	8½	16 0	6½
Royal mast	12 0	—	12 0	—	9 0	—	16 6	—	16 6	—	12 0	—	11 0	—	11 0	—	8 6	—
Pole	2 6	—	2 6	—	1 6	—	3 6	—	3 6	—	3 0	—	2 6	—	2 6	—	2 0	—
Lower yard. Whole length, arms included	80 0	17	80 0	17	60 0	13	78 6	19	78 6	19	65 0	13	67 0	16	67 0	16	43 0	10
Yard arms, each	4 6	—	4 6	—	4 0	—	3 4	—	3 4	—	2 4	—	2 9	—	2 9	—	1 10	—
Topsail yard. Whole length, arms included	61 0	13	61 0	13	45 0	10	59 0	13	59 0	13	43 0	9½	49 6	10½	49 6	10½	34 0	8
	5 0	—	5 0	—	4 6	—	4 11	—	4 11	—	3 7	—	4 8	—	4 8	—	3 0	—
[illegible] included	41 0	6	41 0	6	23 0	5½	40 0	9½	40 0	9½	30 6	7½	32 0	7	32 0	7	22 0	5½
	2 6	-	2 6	—	1 0	—	1 8	—	1 8	—	1 3	—	1 4	—	1 4	—	11	—
[illegible]ded	23 0	6	23 0	6	14 0	3½	20 6	6	29 6	6	23 0	4½	24 0	5	24 0	5	17 0	3½
	1 3	—	1 3	—	1 0	—	1 2	-	1 2	—	1 0	—	1 0	—	1 0	—	8	—
	35 0	9½	35 0	9½	27 6	9½	35 0	9½	35 0	9½	39 0	9½	32 0	8½	32 0	8½	24 0	6
	2 6	—	2 6	—	5 6	—	2 0	—	2 0	—	2 0	—	2 0	—	2 0	—	2 0	—
	—	—	—	—	56 0	13	—	—	—	—	55 6	13	—	—	—	—	—	—
	23 6	30	—	—	—	—	18 0	24	—	—	—	—	19 6	16	—	—	—	—
Jibboom, housing included	67 6	14½	—	—	—	—	51 0	15½	—	—	—	—	33 0	13	—	—	—	—
Housing	33 6	—	—	—	—	—	21 0	—	—	—	—	—	15 0	—	—	—	—	—
Distance before aft side of stern post ‡	242 0	—	135 9	—	82 6	—	232 0	—	139 6	—	45 9	—	176 0	—	91 6	—	35 0	—

* Iron, $\frac{7}{16}$ in. thick. † Iron, [illegible] in. thick. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (continued).

Species of Masts and Spars	Turkish Ironclad 'Sultan Mahmoud.' Length, [illegible] ft. Breadth, 56 ft. Tonnage, 4,[illegible]. Barque-rigged						H.M.S. 'Serapis,' Troopship. Length, 360 ft. Breadth, 49 ft. Tonnage, 4,173. Barque-rigged						H.M.S. 'Valiant,' Ironclad. Length, 280 ft. Breadth, 56 ft. Tonnage, 4,063. Barque-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.	Length	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	57 6	26*	61 0	26*	55 0	24†	49 0	30*	54 0	32*	57 0	18†	57 0	36‡	63 0	37‡	55 0	24‡
Head	16 0	—	16 0	—	12 8	—	14 0	—	15 0	—	10 0	—	20 0	—	20 0	—	12 8	—
Topmast. Whole length, head included	—	—	—	—	—	—	46 6	17	46 6	17	—	—	—	—	—	—	—	—
Head	—	—	—	—	—	—	6 3	—	6 3	—	—	—	—	—	—	—	—	—
Topmast. Length to stops	38 6	18	38 6	18	46 0	12	—	—	—	—	44 0	9	48 0	18	48 0	18	48 0	11
Topgallant mast. Length to stops	22 0	—	22 0	—	—	—	22 6	10½	22 6	10½	—	—	14 0	—	14 0	—	—	—
Royal mast	—	—	—	—	—	—	14 0	—	14 0	—	—	—	—	—	—	—	—	—
Pole	2 6	—	2 6	—	9 0	—	2 0	—	2 0	—	7 0	—	1 0	—	1 0	—	9 0	—
Lower yard. Whole length, arms included	91 0	23	91 0	23	—	—	80 8	18$\frac{3}{16}$	80 0	15$\frac{15}{16}$	—	—	91 0	22	91 0	22	—	—
	3 6	—	3 6	—	—	—	3 6	—	3 6	—	—	—	3 10	—	3 10	—	—	—
Topsail yard. …s included	70 0	17½	70 0	17½	—	—	65 0	14½	65 0	14½	—	—	75 0	15	75 0	15	—	—
Gaff topsail y…	—	—	—	—	20 0	6	—	—	—	—	21 0	5	67 0‖	—	67 0‖	—	20 0	6
…ch	3 10	—	3 10	—	2 0	—	5 0	—	5 0	—	2 0	—	3 6¶	—	3 6¶	—	2 0	—
Topgallant ya… …ms included	44 0	11	44 0	11	—	—	45 6	9½	45 6	9½	—	—	44 0	10	44 0	10	—	—
Yard arms, each	3 0	—	3 0	—	—	—	2 0	—	2 0	—	—	—	3 0	—	3 0	—	—	—
Royal yard. Whole length, arms included	—	—	—	—	—	—	36 0	7	36 0	7	—	—	—	—	—	—	—	—
	—	—	—	—	—	—	1 6	—	1 6	—	—	—	—	—	—	—	—	—
…l.	36 0	10	40 6	10½	37 0	9	35 6	8½	35 6	8½	33 6	8½	36 0	10	40 6	10½	37 0	6½
	—	—	—	—	56 0	12½	—	—	—	—	53 0	12½	—	—	—	—	56 0	12½
	24 6	28	—	—	—	—	20 0	22	—	—	—	—	26 0	32‡	—	—	—	—
	59 0	16	—	—	—	—	38 0	12	—	—	—	—	46 6	14½	—	—	—	—
Distance before aft side of stern post **	239 6	—	126 3	—	59 9	—	266 9	—	134 9	—	60 6	—	229 0	—	119 3	—	59 9	—

* Of iron, $\frac{1}{16}$ in. thick. † Of iron, ⅜ in. thick. ‡ Of iron. § Of steel, ¼ in. thick. ‖ Upper topsail yard.
¶ Arms to lower topsail yard; arms to upper topsail yard = 6 ft. 6 in. each. ** On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAM VESSELS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY (concluded).

Species of Masts and Spars	'Mooltan,' Merchant Steamer. Length, 335 ft. Breadth, 39 ft. Tonnage, 2,531. Barque-rigged						'Europa,' Merchant Steamer. Length, 225 ft. Breadth, 30 ft. 6 in. Tonnage, 1,022. Barque-rigged						'General Mozellos,' Merchant Steamer. Length, 200 ft. Breadth, 29 ft. Tonnage, 816. Barque-rigged					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	52 0	32	55 0	32	47 0	27	44 0	27	49 0	27	48 0	18	44 0	18	49 0	18	39 0	12
Head	14 6	—	14 6	—	11 0	—	12 0	—	12 0	—	8 0	—	11 0	—	11 0	—	8 0	—
Topmast. Whole length, head included	46 0	17	46 0	17	—	—	36 0	14	36 0	14	—	—	—	—	—	—	—	—
Head	7 0	—	7 0	—	—	—	6 0	—	6 0	—	—	—	—	—	—	—	—	—
Topmast. Length to stops	—	—	—	—	32 0	18	—	—	—	—	47 0	10½	25 3	11	25 3	11	27 6	7½
Topgallant mast. Length to stops	24 0	11	24 0	11	—	—	19 0	7½	19 0	7½	—	—	15 0	—	15 0	—	—	—
Royal mast	15 0	—	15 0	—	—	—	14 6	—	14 6	—	—	—	—	—	—	—	—	—
Pole	6 0	—	6 0	—	11 0	—	4 6	—	4 6	—	4 0	—	7 0	—	7 0	—	8 0	—
Lower yard. Whole length, arms included	75 0	17	75 0	17	—	—	70 0	16½	70 0	16½	—	—	64 0	18	64 0	18	—	—
Yard arms, each	5 0	—	5 0	—	—	—	3 0	—	3 0	—	—	—	3 6	—	3 6	—	—	—
Topsail yard. Whole length, arms included	57 0	12¾	57 0	12¾	—	—	55 0	12½	55 0	12½	—	—	49 0	9½	49 0	9½	—	—
Gaff topsail yard. Whole length	—	—	—	—	*	—	—	—	—	—	*	—	—	—	—	—	16 6	4½
Yard arms, each	6 0	—	6 0	—	—	—	4 0	—	4 0	—	—	—	4 0	—	4 0	—	—	—
Topgallant yard. Whole length, arms included	36 0	7½	36 0	7½	—	—	38 0	7½	38 0	7½	—	—	28 6	6½	28 6	6½	—	—
Yard arms, each	3 0	—	3 0	—	—	—	2 6	—	2 6	—	—	—	2 0	—	2 0	—	—	—
Royal yard. Whole length, arms included	—	—	—	—	—	—	26 0	6	26 0	6	—	—	—	—	—	—	—	—
Yard arms, each	—	—	—	—	—	—	1 6	—	1 6	—	—	—	—	—	—	—	—	—
Gaff. Whole length, fly included	38 6	9½	39 6	9½	32 6	9½	33 0	9½	33 0	9½	29 0	8½	31 0	8	31 0	8	30 0	7½
Spanker boom. Whole length	—	—	—	—	52 0	11	—	—	—	—	42 0	10½	—	—	—	—	41 0	9
Bowsprit, exclusive of housing	33 0	30	—	—	—	—	27 0	26	—	—	—	—	18 9	17	—	—	—	—
Jibboom " "	35 0	14½	—	—	—	—	24 0	14	—	—	—	—	26 0	8	—	—	—	—
Distance before aft side of stern post †	258 0	—	144 6	—	55 3	—	177 0	—	98 0	—	34 0	—	154 0	—	83 6	—	33 0	—

* Jib-headed topsail on mizen mast.

† On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME MERCHANT VESSELS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

Species of Masts and Spars	Sailing Vessel 'Haddington.' Lgth., 180 ft. Brdth., 35 ft. 6 in. Tonnage, 1,333, Barque-rigged						Screw Steamer 'Tanjore.'* Length, 280 ft. Breadth, 30 ft. Tonnage, 2,139				Screw Steamer 'Charkieh.'* Length, 260 ft. Breadth, 35 ft. Tonnage, 1,557				Sailing Vessel 'Mutlah.'* Length, 115 ft. Breadth, 25 ft. Tonnage, 280			
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to trussel trees	52 0	31	56 0	31	52 0	22	50 0	30	53 0	30	46 0	27	51 0	27	48 6	18	51 0	18
Head	15 6	—	16 6	—	11 0	—	14 0	—	14 0	—	12 0	—	12 0	—	9 6	—	9 6	—
Topmast. Whole length, head included	52 6	17	52 6	17	—	—	47 0	17½	47 0	17½	39 0	14½	39 0	14½	34 3	11½	34 3	11½
Head	7 6	—	7 6	—	—	—	7 0	—	7 0	—	6 0	—	6 0	—	4 9	—	4 9	—
Topmast. I	—	—	—	—	56 0	13	—	—	—	—	—	—	—	—	—	—	—	—
Topgallant ı … stops	24 6	10½	24 6	10½	—	—	24 0	11½	24 0	11½	21 0	10½	21 0	10½	16 0	6½	16 0	6½
… at	14 6	—	14 6	—	—	—	—	—	—	—	—	—	—	—	8 6	4½	9 6	4½
	2 0	—	2 0	—	12 0	—	16 0	9½	16 0	9½	11 0	8½	11 0	8½	2 0	—	2 0	—
Lower yard. Whole length, arms included	84 0	20	84 0	20	—	—	78 0	17½	78 0	17½	70 0	16	70 0	16	51 9	11½	56 6	12
Yard arms, each	4 0	—	4 0	—	—	—	5 0	—	5 0	—	4 0	—	4 0	—	2 6	—	2 6	—
Topsail yard. Whole length, arms included	64 0	15	64 0	15	—	—	56 0	14	56 0	14	55 0	13	55 0	13	34 6	6½	38 6	7
	5 0	—	5 0	—	—	—	5 0	—	5 0	—	5 0	—	5 0	—	2 0	—	2 0	—
Topgallant ya… …luded	42 0	10	42 0	10	—	—	40 0	9	40 0	9	36 0	8	36 0	8	25 9	5½	26 9	6
	2 0	—	2 0	—	—	—	2 0	—	2 0	—	3 0	—	3 0	—	1 0	—	1 0	—
Royal yard. …l	30 0	7	30 0	7	—	—	—	—	—	—	—	—	—	—	19 6	4½	19 9	4½
Yard arms, each	1 3	—	1 3	—	—	—	—	—	—	—	—	—	—	—	1 0	—	1 0	—
Gaff. Whole length	35 6	11	35 6	11	32 0	10½	40 0	9½	40 0	9½	35 6	8	38 6	8	—	—	25 6	6½
Fly	2 6	—	2 6	—	4 0	—	5 0	—	5 0	—	5 0	—	5 0	—	—	—	1 6	—
Spanker boom	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	†55 6	11½
Bowsprit, exclusive of housing	36 0	30	—	—	—	—	43 0	26	—		36 0	22	—	—	24 0	18	—	—
Jibboom " "	34 0	14	—	—	—	—	—	—	—	—	—	—	—	—	35 0	10	—	—
Distance before aft side of stern post ‡	175 6	—	94 6	—	85 0	—	213	—	96 3	—	191 6	—	71 6	—	87 0	—	39 9	—

* Brig-rigged. † Main boom. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCREW STEAMERS AS BUILT BY THE THAMES IRONWORKS AND SHIPBUILDING COMPANY.

Species of Masts and Spars	'Vasco de Gama,' Portuguese Ironclad. Length, 200 ft. Breadth, 40 ft. Tonnage, 1,487. 3-masted Schooner						'Alexandria,' , 30 ft. 3-masted Schooner						H.M.S. 'Swift,' , 30 ft. 3-masted Schooner					
	Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast		Fore Mast		Main Mast		Mizen Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. Deck to trussel trees	*45 0	22	*49 0	22	41 0	16	44 0	19½	47 0	18½	37 6	13	38 9	10½	41 8	10½	37 6	11
Head	10 0	—	10 0	—	7 0	—	10 0	—	10 0	—	6 6	—	7 8	—	7 6	—	7 0	—
Topmast. Length to stops	27 0	12	38 6	11	31 0	8	35 6	10	41 0	9½	35 0	8	19 6	8¼	31 6	8¼	24 6	6½
Topgallant mast	18 6	—	—	—	—	—	16 0	—	—	—	—	—	10 0	—	—	—	—	—
Royal mast	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pole	2 6	—	6 6	—	5 0	—	5 0	—	6 0	—	6 0	—	4 0	—	4 0	—	5 0	—
Lower yard. Whole length	60 0	14	—	—	—	—	66 0	14½	—	—	—	—	46 0	10½	—	—	—	—
Yard arms, each	3 0	—	—	—	—	—	4 0	—	—	—	—	—	2 0	—	—	—	—	—
Topsail yard. Whole length	41 0	10	—	—	—	—	49 0	10	—	—	—	—	32 6	7	—	—	—	—
Gaff topsail yard. Whole length	—	—	20 0	6	14 0	4½	—	—	19 0	6	15 6	5	—	—	†	—	†	—
Yard arms, each	3 0	—	2 6	—	1 6	—	4 6	—	2 0	—	1 6	—	3 0	—	—	—	—	—
Topgallant yard. Whole length	28 0	7	—	—	—	—	33 6	7½	—	—	—	—	20 0	4½	—	—	—	—
Yard arms, each	1 9	—	—	—	—	—	2 6	—	—	—	—	—	1 2	—	—	—	—	—
Royal yard. Whole length	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yard arms, each	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Gaff. Whole length, fly included	29 0	8½	29 0	8½	24 0	6½	31 0	8	35 0	8½	27 0	6½	22 0	7½	22 0	7½	14 6	5½
Fly	2 0	—	2 0	—	1 6	—	2 0	—	2 0	—	1 6	—	1 0	—	—	—	—	—
Boom. Whole length	—	—	—	—	34 0	8	42 6	10	47 0	10½	28 6	9	—	—	—	—	26 0	9
Bowsprit, exclusive of housing	16 0	17	—	—	—	—	23 0	18	—	—	—	—	16 0	13	—	—	—	—
Jibboom " "	41 0	11	—	—	—	—	23 0	13	—	—	—	—	15 0	7½	—	—	—	—
Distance before rudder post ‡	141 0	—	66 0	—	23 0	—	161 0	—	91 0	—	29 6	—	124 0	—	64 6	—	17 8	—

* Of iron. † Jib-headed topsail. ‡ On load water-line.

TABLE GIVING THE DIMENSIONS OF MASTS AND SPARS OF SOME SCHOONER-RIGGED SCREW STEAMERS.

Species of Masts and Spars	Length, 150 ft. Breadth, 36 ft. Tonnage, 483. Schooner-rigged *				Length, 130 ft. Breadth, 20 ft. Tonnage, 251. Schooner-rigged				Length, 108 ft. Breadth, 17 ft. 6 in. Tonnage, 159. Schooner-rigged				Length, 76 ft. Breadth, 15 ft. Tonnage, 86. Fore and Aft Schooner			
	Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast		Fore Mast		Main Mast	
	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.	Lgth.	Dia.
	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.	ft. in.	in.
Lower mast. From deck to hounds	42 6	15	44 0	14½	39 0	15	41 0	14	37 0	14	38 0	13	26 3	12	28 6	11
Head	10 0	—	10 0	—	8 0	—	8 0	—	7 6	—	7 6	—	—	—	—	—
Topmast. Length to stops	21 0	10	36 6	9	16 0	7	28 0	7	26 0	9½	27 0	9	20 0	—	20 0	—
Pole	—	—	3 6	—	—	—	4 0	—	3 0	—	3 0	—	3 0	—	4 0	—
Topgallant mast. Length to stops	12 6	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Pole	3 0	—	—	—	4 0	—	—	—	—	—	—	—	—	—	—	—
Lower yard. Whole length	60 0	10½	—	—	46 0	8	—	—	41 0	9½	—	—	—	—	—	—
Yard arms, each	3 0	—	—	—	2 0	—	—	—	2 6	—	—	—	—	—	—	—
Topsail yard. Whole length	44 6	8	—	—	34 0	7	—	—	24 0	8	—	—	—	—	—	—
Gaff topsail yard. Whole length	—	—	14 0	5	—	—	18 0	6	—	—	19 0	11	11 0	4	13 0	4½
Yard arms, each	4 0	—	2 0	—	2 6	—	1 6	—	2 0	—	2 0	—	1 0	—	1 6	—
Topgallant yard. Whole length	29 0	5¾	—	—	21 0	5	—	—	—	—	—	—	—	—	—	—
Yard arms, each	2 0	—	—	—	1 6	—	—	—	—	—	—	—	—	—	—	—
Gaff. Whole length, fly included	31 0	6¼	34 0	6¾	19 0	6	27 0	7	25 0	7½	26 6	7½	17 0	5½	18 6	5½
Fly	2 0	—	2 0	—	2 0	—	2 0	—	2 6	—	3 0	—	1 3	—	2 0	—
Spanker boom	—	—	53 0	11	—	—	45 0	10	—	—	28 0	7	—	—	28 0	7
Bowsprit, exclusive of housing	28 0	10½	—	—	18 0	12	—	—	21 0	11	—	—	14 6	9	—	—
Jibboom ,, ,,	—	—	—	—	15 0	5	—	—	—	—	—	—	—	—	—	—
Housing	—	—	—	—	10 0	—	—	—	—	—	—	—	—	—	—	—
Distance before rudder post †	114 0	—	45 6	—	92 6	—	41 0	—	81 6	—	34 3	—	57 0	—	24 0	—

* Sloop of war. † On load water-line.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS.

Species of Masts and Spars		Clipper Ships		Screw Vessels				
				Ironclad Frigates		Wood-sheathed Corvette	Troop-ship	Merchant Steamer
		Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Main mast hounded . .	= breadth of vessel . . . ×	1·889	1·408	1·141	·947	1·236	1·217	1·440
" " headed . .	= hounded length . . . ×	·254	·262	·302	·338	·288	·259	·248
Fore " hounded . .	= main mast hounded . . . ×	·910	·911	·908	·944	·904	·946	·958
" " headed . .	= hounded length . . . ×	·281	·309	·315	·358	·298	·278	·259
Mizen " hounded . .	= main mast hounded . . . ×	·905	·911	·828	·889	·875	·898	·848
" " headed . .	= hounded length . . . ×	·246	·289	·289	·260	·219	·222	·215
Main topmast hounded . .	= breadth of vessel . . . ×	1·086	1·125	·987	·808	1·000	·945	·976
" " headed . .	= hounded length . . . ×	·211	·185	·155	·141	·155	·172	·167
Fore " hounded . .	= 1 . . ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" " headed . .	= 1 . . ×	·211	·185	·155	·141	·155	·172	·167
Mizen " hounded . .	= 1 . . ×	·808	·827	·777	·789	·774	·786	·782
" " headed . .	= 1 . . ×	·238	·194	·154	·147	·154	·156	·188
Main topgallant mast hounded	= breadth of vessel . . . ×	·632	·958	·548	·456	·595	·511	·548
" royal " "	= " " " . . . ×	·426	·500	·362	·289	·369	·305	·286
" " " pole .	= hounded length . . . ×	·879	—	·191	·364	·096	·178	·208
" skysail " hounded	= breadth of vessel . . . ×	—	·361	—	—	—	—	—
" " " pole .	= hounded length . . . ×	—	·077	—	—	—	—	—
Fore topgallant " hounded	mast hounded ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" royal " "	t hounded . ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" " " pole .	. . . ×	·879	—	·191	·364	·094	·178	·208
" skysail " hounded	ast hounded . ×	—	1·000	—	—	—	—	—
" " " pole .	. . . ×	—	·077	—	—	—	—	—
Mizen topgallant " hounded	= main topgallant mast hounded ×	·600	·826	·746	·769	·780	·798	·849
" royal " "	= " royal mast hounded . ×	·828	·778	·762	·818	·774	·786	·750

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS (continued).

Species of Masts and Spars			Clipper Ships Ex. 1	Clipper Ships Ex. 2	Screw Vessels: Ironclad Frigates Ex. 1	Ironclad Frigates Ex. 2	Wood-sheathed Corvette	Troop-ship	Merchant Steamer
Mizen royal mast pole	= hounded length	×	·454	—	·190	·800	·085	·136	·208
" skysail mast hounded	= main skysail mast hounded	×	—	·846	—	—	—	—	—
" " pole	= hounded length	×	—	·090	—	—	—	—	—
Main yard. Whole length	= length on water-line	×	·358	·858	·278	·284	·291	·288	·268
Yard arms, each	= yard	×	·037	·036	·041	·044	·042	·050	·056
Fore yard.	= main yard	×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
	= yard	×	·087	·036	·041	·044	·042	·050	·056
Mizen yard.	= main yard	×	·789	·857	·676	·744	·701	·750	·755
Yard arms, each	= yard	×	·038	·038	·042	·094	·042	·100	·067
Main lower topsail yard	= main yard	×	·848	·877	—	—	—	—	—
Yard arms, each	= yard	×	·024	·052	—	—	—	—	—
Fore lower topsail yard	= main lower topsail yard	×	1·000	1·000	—	—	—	—	—
Yard arms, each	= yard	×	·024	·052	—	—	—	—	—
Mizen lower topsail yard	= main lower topsail yard	×	·770	·829	—	—	—	—	—
Yard arms, each	= yard	×	·026	·058	—	—	—	—	—
Main upper topsail yard	= main yard	×	·919*	·933*	·705	·744	·750	·800	·762
Yard arms, each	= yard	×	·052	·082	·081	·094	·085	·078	·082
Fore upper topsail yard	= main upper topsail yard	×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard	×	·052	·082	·081	·081	·085	·078	·082
Mizen upper topsail yard	= main upper topsail yard	×	·808	·794	·696	·672	·729	·687	·788
Yard arms, each	= yard	×	·038	·040	·082	·061	·068	·079	·100
Main topgallant yard	= main upper topsail yard	×	·816	·816	·622	·672	·678	·641	·672
Yard arms, each	= yard	×	·049	·039	·048	·061	·042	·061	·061

* Main lower topsail yard.

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR FULL-RIGGED SHIPS (concluded).

Species of Masts and Spars			Clipper Ships		Screw Vessels				
					Ironclad Frigates		Wood-sheathed Corvette	Troop-ship	Merchant Steamer
			Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Fore topgallant yard	= main topgallant yard	×	·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard	×	·049	·039	·048	·061	·042	·061	·061
Mizen topgallant yard	= main topgallant yard	×	·774	·762	·728	·711	·737	·732	·561
Yard arms, each	= yard	×	·035	·040	·042	·039	·044	·042	·045
Main royal yard	= main topgallant yard	×	·818	·742	·706	·667	·737	·732	·683
Yard arms, each	= yard	×	·047	·040	·042	·042	·044	·042	·045
Fore royal yard	= main royal yard	×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard	×	·047	·040	·042	·042	·044	·042	·045
Mizen royal yard	= main royal yard	×	·737	·76	·754	·717	·779	·738	·500
Yard arms, each	= yard	×	·045	·034	·042	·046	·040	·045	·071
Main skysail yard	= main royal yard	×	—	·778	—	—	—	—	—
Yard arms, each	= yard	×	—	·084	—	—	—	—	—
Fore skysail yard	= main skysail yard	×	—	1·000	—	—	—	—	—
Yard arms, each	= yard	×	—	·084	—	—	—	—	—
Mizen skysail yard	= main skysail yard	×	—	·690	—	—	—	—	—
Yard arms, each	= yard	×	—	·087	—	—	—	—	—
Spanker gaff. Whole length	= spanker boom	×	·677	·785	·700	·700	·670	·660	·669
„ boom. „	= length of vessel	×	·216	·216	·184	·199	·197	·166	·188
Bowsprit, outside stem	= „ „ „	×	·103	·102	·129	·102	·075	·099	·112
Jibboom, housing excluded	= „ „ bowsprit	×	1·768	1·909	1·000	1·415	2·250	1·813	2·015
Housing	= „ „ jibboom	×	·527	·524	·387	·348	·466	·552	·496
Fore mast before after sternpost	= „ „ water-line	×	·771	·779	·575	·774	·826	·777	·809
Main „ „	= „ „ „	×	·452	·463	·425	·480	·441	·335	·455
Mizen „ „	= „ „ „	×	·190	·174	·161	·164	·161	·117	·175

Main mast hounded	= breadth of vessel	×	1·125	1·126	1·410	1·606	1·102	1·395	1·577
" " headed	= hounded length	×	·254	·317	·264	·245	·278	·264	·276
Fore " hounded	= main mast hounded	×	·913	·905	·927	·898	·908	·943	·928
" " headed	= hounded length	×	·278	·351	·282	·272	·286	·280	·298
Mizen " hounded	= main mast hounded	×	·878	·873	·887	·979	1·056	—	·928
" " headed	= hounded length	×	·230	·228	·284	·167	·175	—	·211
Main topmast hounded	= breadth of vessel	×	·687	·857	1·000	1·000	·820	1·052	1·267
" " headed	= hounded length	×	—	—	·179	·167	·134	·175	·167
Fore " hounded		×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" " headed		×	—	—	·179	·167	·134	·175	·167
Mizen " hounded		×	1·247	1·000	·821	1·567	1·093	—	1·289
" " pole		×	·188	·188	·344	·086	·159	—	·207
Main topgallant mast hounded		×	·898	·250	·615	·623	·459	·631	·690
" " " pole	= hounded length	×	·114	·071	·500	—	—	·667	—
Fore " " hounded	= 1 ast hounded	×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
" " " pole	= l	×	·114	·071	·500	—	—	·667	—
Main royal mast hounded	= breadth of vessel	×	—	—	—	·475	·286	—	·408
" " " pole	= hounded length	×	—	—	—	·310	·148	—	·188
Fore " " hounded	= main royal mast pole	×	—	—	—	1·000	1·000	—	1·000
" " " pole	= hounded length	×	—	—	—	·310	·148	—	·188
Main yard. Whole length	= length of water-line	×	·205	·325	·224	·311	·217	·260	·382
Yard arms, each	= yard	×	·067	·050	·066	·048	·044	·064	·047
Fore yard. Whole length	= main yard	×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard	×	·067	·050	·066	·048	·044	·064	·047

TABLE OF FACTORS USED TO DETERMINE THE LENGTHS OF MASTS AND SPARS FOR BARQUES AND BRIGS (concluded).

SPECIES OF MASTS AND SPARS		Screw Steam Vessels						Sailing Merchant Vessel. Barque-rigged
		Ironclad Frigates. Barque-rigged		Merchant Vessels. Barque-rigged		Troop-ship. Barque-rigged	Merchant Vessel. Brig-rigged	
		Ex. 1	Ex. 2	Ex. 1	Ex. 2			
Main topsail yard	= main yard ×	·769	·736	·760	·785	·812	·743	·762
Yard arms, each	= yard ×	·055	·074	·105	·073	·077	·086	·078
Fore topsail yard	= main topsail yard ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard ×	·055	·074	·105	·073	·077	·086	·078
Mizen gaff topsail yard	= spanker gaff ×	·540	·543	—*	—*	·591	—*	—*
Yard arms, each	= yard ×	·100	·100	—	—	·095	—	—
Main topgallant yard	= main topsail yard ×	·628	·657	·631	·690	·700	·689	·656
Yard arms, each	= yard ×	·068	·068	·083	·066	·045	·050	·048
Fore topgallant yard	= main topgallant yard ×	1·000	1·000	1·000	1·000	1·000	1·000	1·000
Yard arms, each	= yard ×	·068	·068	·083	·066	·045	·050	·048
Main royal yard	= main topgallant yard ×	—	—	—	·684	·791	—	·714
Yard arms, each	= yard ×	—	—	—	·058	·041	—	·042
Fore royal yard	= main royal yard ×	—	—	—	1·000	1·000	—	1·000
Yard arms, each	= yard ×	—	—	—	·058	·041	—	·042
Spanker gaff. Whole length	= spanker boom ×	·661	·661	·625	·700	·670	·133†	·145†
„ boom „ „	= length of vessel ×	·191	·200	·155	·187	·147	—	—
Bowsprit, outside stem	= „ „ „ ×	·081	·089	·097	·120	·056	·143	·164
Jibboom, housing excluded	= „ „ bowsprit ×	1·306	1·181	1·061	·900	1·300	—	·944
Housing	= „ „ jibboom ×	·782	·548	·943	·945	·461	—	·471
Fore mast before rudder post	= „ „ water-line ×	·817	·818	·770	·787	·796	·706	·798
Main „ „	= „ „ „ ×	·431	·426	·431	·436	·374	·287	·430
Mizen „ „	= „ „ „ ×	·204	·209	159	·151	·141	—	·160

* Jib-headed topsail. † Spanker gaff = length of vessel ×.

			Schooner	rigged	rigged	Schooner	rigged	rigged	Schooner	
Fore mast hounded	= breadth of vessel	×	1·125	1·127	1·634	1·467	1·950	2·133	1·758	1·740
„ „ headed	= hounded length	×	·222	·287	·285	·230	·205	·202	—	·218
Main „ hounded	= fore mast hounded	×	1·089	1·125	1·035	1·068	1·051	1·027	1·057	1·172
„ „ headed	= hounded length	×	·204	·211	·230	·218	·195	·200	—	·186
Mizen „ hounded	= fore mast hounded	×	·911	—	—	·848	—	—	—	—
„ „ headed	= hounded length	×	·171	—	—	·173	—	—	—	—
Fore topmast hounded	= breadth of vessel	×	·675	·76	·807	·850	·800	1·500	1·838	1·368
„ „ headed	= hounded length	×	—	—	—	—	—	—	—	·140
„ „ pole	= „ „	×	—	—	—	—	—	·115	·150	—
Main „ hounded	= fore topmast hounded	×	1·426	1·370	1·788	1·608	1·75	1·04	1·000	1·368
„ „ headed	= hounded length	×	—	—	—	—	—	—	—	·140
„ „ pole	= „ „	×	·170	·185	·100	·146	·143	·112	·200	—
Mizen „ hounded	= fore topmast hounded	×	1·148	—	—	·100	—	—	—	—
„ „ pole		×	·161	—	—	·200	—	—	—	—
Fore topg. mast hounded	= breadth of vessel	×	·340	·894	·481	·588	·500	—	—	·600
„ „ „ pole	= hounded length	×	·185	·111	·236	·312	·400	—	—	—
Main „ „ hounded	= fore topg. mast hounded	×	—	—	—	—	—	—	—	1·067
Fore royal „ „	= breadth of vessel	×	—	—	—	—	—	—	—	·367
„ „ „ pole	= hounded length	×	—	—	—	—	—	—	—	·285
Main „ „ hounded	= fore royal mast hounded	×	—	—	—	—	—	—	—	1·117
„ „ „ pole	= hounded length	×	—	—	—	—	—	—	—	·211
Fore yard. Whole length	= length of vessel	×	·300	·265	·400	·810	·354	·380	—	·450
Yard arms, each	= yard	×	·050	·065	·050	·060	·048	·061	—	·048

Table of Factors used to Determine the Lengths of Masts and Spars of Schooners and Brigs (concluded).

Species of Masts and Spars	Screw Steam Vessels: Ironclads: 3-masted Schooner	Screw Steam Vessels: Ironclads: Schoon.-rigged	Screw Steam Vessels: Sloop of War. Schoon.-rigged	Screw Steam Vessels: Merchant Vessels: 3-masted Schooner	Screw Steam Vessels: Merchant Vessels: Schoon.-rigged	Screw Steam Vessels: Merchant Vessels: Schoon.-rigged	Screw Steam Vessels: Merchant Vessels: Fore and Aft Schooner	Merchant Sailing Vessel. Brig-rigged
Main yard. Whole length . . = fore yard . ×	—	—	—	—	—	—	—	1·072
Yard arms, each . . = yard . . ×	—	—	—	—	—	—	—	·045
Fore topsail yard. Whole length . = fore yard . ×	·683	·647	·741	·754	·739	·585	*	·705
Yard arms, each = yard . . ×	·078	·076	·090	·092	·074	·083	—	·055
Main topsail yard. Whole length . = fore tops. yard ×	—	—	—	—	—	—	—	1·055
Yard arms, each = yard . . ×	—	—	—	—	—	—	—	·055
Main gaff topsail yard. Whole length = main gaff . ×	·690	·617	·412	·542	·667	·709	·702	—
Mizen " " " = mizen gaff . ×	·588	—	—	·574	—	—	—	—
Fore topgallant yard. Whole length = fore tops. yard ×	·683	·683	·655	·661	·653	—	—	·705
Yard arms, each = yard . . ×	·068	·074	·073	·072	·071	—	—	·035
Main topgallant yard. Whole length = fore topg. yard ×	—	—	—	—	—	—	—	1·040
Yard arms, each = yard . . ×	—	—	—	—	—	—	—	·035
Fore royal yard. Whole length . = fore topg. yard ×	—	—	—	—	—	—	—	·756
Yard arms, each . = yard . . ×	—	—	—	—	—	—	—	·050
Main royal yard. Whole length . = fore royal yard ×	—	—	—	—	—	—	—	1·128
Yard arms, each . = yard . . ×	—	—	—	—	—	—	—	·050
Fore gaff. Whole length . . . = lgth. of vessel ×	·145	·121	·206	·152	·146	·281	·228	·317
Main " " . . . = fore gaff . ×	1·000	1·214	1·100	1·127	1·142	1·060	1·088	1·000
Mizen " " . . . = " " . ×	·837	—	—	·871	—	—	—	—
Spanker boom. Whole length . . = mizen gaff . ×	1·416	1·53	1·560	1·425	1·700	1·056	1·518	†
Bowsprit, exclusive of housing . . = lgth. of vessel ×	·080	·105	·187	·105	·100	·200	·191	·218
Jibboom " " " . . = " jibb. . ×	2·562	—	—	1·000	1·230	—	—	1·728
Distance of fore mast bef. rudder post = " vessel ×	·705	·721	·760	·767	·711	·754	·750	·756
" main " " = " " ×	·330	·298	·303	·483	·315	·317	·316	·345
" mizen " " = " " ×	·115	—	—	·141	—	—	—	—

* Fore gaff topsail yard = fore gaff × ·647

† Main boom = main gaff × 1·523.

TABLE SHOWING THE SIZES AND TOTAL WEIGHTS OF THE STANDING RIGGING OF SAILING VESSELS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

Species of Standing Rigging	Ship, 1,300 T. Girth (ins.) Hemp	Ship, 1,300 T. Girth (ins.) Wire	Ship, 1,150 T. Girth (ins.) Hemp	Ship, 1,150 T. Girth (ins.) Wire	Ship, 900 T. Girth (ins.) Hemp	Ship, 900 T. Girth (ins.) Wire	Ship, 750 T. Girth (ins.) Hemp	Ship, 750 T. Girth (ins.) Wire	Ship, 600 T. Girth (ins.) Hemp	Ship, 600 T. Girth (ins.) Wire	Ship, 500 T. Girth (ins.) Hemp	Ship, 500 T. Girth (ins.) Wire	Ship, 400 T. Girth (ins.) Hemp	Ship, 400 T. Girth (ins.) Wire	Bark, 300 T. Girth (ins.) Hemp	Bark, 300 T. Girth (ins.) Wire	Bark, 200 T. Girth (ins.) Hemp	Bark, 200 T. Girth (ins.) Wire	Brig, 270 T. Girth (ins.) Hemp	Brig, 270 T. Girth (ins.) Wire
Fore & main shrouds	10	4	9½	3⅞	9	3¾	8½	3½	8	3⅜	7½	3¼	7	2⅞	6¾	2¾	6	2⅜	6½	2⅝
Mizen shrouds	8	3⅜	7½	3¼	7½	3	7	2⅞	6¾	2¾	6½	2⅝	5¾	2¼	5½	2⅜	4½	1⅞	—	—
Fore stays (double)	10	4	9½	3⅞	9	3¾	8½	3⅝	—	—	7½	3⅜	7½	3⅜	—	—	6	2⅜	6½	2⅝
" (single)	—	—	—	—	—	—	—	—	8½	3½	—	—	—	—	8½	3⅜	—	—	—	—
Main stays (double)	10	4	9½	3⅞	—	—	8½	3⅝	—	—	7½	3⅜	7½	3⅜	—	—	—	—	—	—
" (single)	—	—	—	—	13½	5¼	—	—	8½	3½	—	—	—	—	8½	3⅝	8	3⅜	8½	3½
Mizen stay (single)	8	3⅜	7¾	3¼	7½	3⅜	7½	3	7	2⅞	6¾	2¾	6½	2⅝	6	2⅜	5½	2⅛	—	—
Fore & main shrouds	6½	2¾	6	2⅜	5¾	2¼	5½	2⅛	5	2	4½	1⅞	4	1¾	3¾	1⅝	3¾	1⅝	3¾	1⅝
Mizen shrouds	5¼	2⅛	5½	2⅛	5	2	4½	1⅞	4	1¾	4	1¾	3¼	1⅝	3	1½	3	1½	—	—
Fore stays (double)	9	3¼	8½	3⅜	8½	3½	8	3⅜	7½	3⅛	7	2⅞	6½	2⅝	5½	2⅜	4½	1⅞	5½	2⅛
" (single)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Main stays (double)	9	3¾	8½	3⅝	—	—	8	3⅜	—	—	—	—	—	—	—	—	—	—	—	—
" (single)	—	—	—	—	8¾	3¾	—	—	8	3⅜	8	3⅜	7½	3⅛	7	2⅞	6	2⅜	6	2⅜
Mizen stay "	6½	2⅝	6¼	2½	6	2⅜	5½	2⅛	5½	2⅜	5	2	4½	1⅞	4	1¾	3¾	1⅝	—	—
Fore & main backstays	9	3¾	8½	3⅜	8¼	3⅜	8	3⅜	7½	3⅜	7½	3⅛	6¾	2¾	6	2⅜	4½	1⅞	5½	2⅛
Mizen backstays	7½	3⅛	7	2⅞	6½	2⅝	6¼	2½	6	2⅜	5¾	2¼	5½	2⅛	5	2	4	1¾	—	—
Fore & main shrouds	5	2	5	2	4½	1⅞	4½	1⅞	4	1¾	3¾	1⅝	3	1½	—	—	—	—	3	1½
masts: Mizen shrouds	4	1¾	4	1¾	3¾	1⅝	3¾	1⅝	3	1½	3	1½	2¾	1	—	—	—	—	—	—
Fore & main stays	6	2⅜	5¾	2¼	5½	2¼	5	2	5	2	4½	1⅞	4½	1⅞	4	1¾	3¾	1⅝	3¾	1⅝
Mizen stay	4½	1⅞	4½	1⅞	4	1¾	4	1¾	3¾	1⅝	3¾	1⅝	3	1½	3	1½	2¾	1	—	—
Fore & main backstays	6½	2⅝	6¼	2½	6	2⅜	5¾	2¼	5½	2⅜	5	2	4½	1⅞	4	1¾	3¾	1⅝	4	1¾
Mizen backstays	5¾	2¼	5½	2⅜	5	2	5	2	4½	1⅞	4½	1⅞	4	1¾	—	—	—	—	—	—
Fore & main stays	4½	1⅞	4	1¾	4	1¾	3¾	1⅝	3¾	1⅝	3	1½	3	1½	2¾	1	—	—	2¾	1
masts: Mizen stay	3¾	1⅝	3¾	1⅝	3¾	1⅝	3	1½	3	1½	2¾	1	2¾	1	—	—	—	—	—	—
Fore & main backstays	5	2	5	2	4½	1⅞	4½	1⅞	4½	1⅞	4½	1⅞	3¾	1⅝	3¾	1⅝	—	—	3	1½
Mizen backstays	4	1¾	4	1¾	3¾	1⅝	3¾	1⅝	3¾	1⅝	3	1½	3	1½	—	—	—	—	—	—
Fore & main stays	3½	1½	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
masts: Mizen stay	3	1¼	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Fore & main backstays	4	1¾	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mizen backstays	3½	1½	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Outer jib stay	8	3⅜	8	3⅜	7½	3⅛	7	2⅞	7	2⅞	6½	2⅝	6½	2⅝	5½	2⅛	5	2	5½	2⅛
Inner "	—	—	8	3⅜	7½	3⅛	7	2⅞	7	2⅞	6½	2⅝	—	—	—	—	—	—	—	—
Flying "	6½	2⅝	6	2⅜	5¾	2¼	5¾	2¼	5½	2⅛	—	—	5	2	4½	1⅞	—	—	4½	1⅞
Standing guys	9	3¾	8½	3⅜	8	3⅜	8	3⅜	7½	3⅛	7	2⅞	6½	2⅝	5¾	2¼	5	2	5¾	2¼
Flying "	6½	2⅝	6½	2⅝	6	2⅜	5¾	2¼	5½	2⅛	—	—	5	2	4½	1⅞	—	—	4½	1⅞

	Ship, 1,300 T.	Ship, 1,150 T.	Ship, 900 T.	Ship, 750 T.	Ship, 600 T.	Ship, 500 T.	Ship, 400 T.	Bark, 300 T.	Bark, 200 T.	Brig, 270 T.
	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.	Cwt. Qr. Lb.
Total wt. of hemp rigging	186 0 16	148 1 20	126 1 14	110 0 18	93 3 24	69 0 27	59 2 16	40 2 17	25 2 24	31 2 5
" wire "	105 2 11	88 0 8	73 1 9	64 1 6	53 2 9	41 2 21	34 1 12	22 2 15	14 0 17	17 3 21

TABLE SHOWING THE SIZES AND TOTAL WEIGHTS OF THE STANDING RIGGING OF STEAM SHIPS WHEN MADE OF MESSRS. R. S. NEWALL AND CO.'S PATENT IMPROVED WIRE ROPE, COMPARED WITH RIGGING MADE OF THE BEST HEMP ROPE.

	Species of Standing Rigging	3,000 Tons Girth (ins.) Hemp	Wire	2,500 Tons Girth (ins.) Hemp	Wire	2,000 Tons Girth (ins.) Hemp	Wire	1,600 Tons Girth (ins.) Hemp	Wire	1,300 Tons Girth (ins.) Hemp	Wire
Lower masts	Fore & main shrouds	10½	4½	10½	4½	10	4½	10	4½	10	4
	Mizen shrouds	7	3½	7	3½	6½	3	6½	3	6½	3½
	Fore & main stays (dbl.)	13½	5	12½	4½	12	4½	11½	4½	11½	4½
	Mizen stay (single)	7½	3½	7½	3½	7½	3½	7	3½	6½	3½
Topmasts	Fore & main shrouds	6	2¾	5½	2¾	5½	2¾	5½	2¾	5½	2½
	Mizen shrouds	4½	2½	4½	2½	4½	2½	4½	2½	4	1¾
	Fore & main stays (dbl.)	9½	4	9½	3½	9½	3½	9	3½	8½	2½
	Mizen stay (single)	6½	3	6½	3	6	2½	6½	2½	6	2½
	Fore & main backstays	9½	4	9½	3½	9½	3½	9	3½	8½	3½
	Mizen backstays	6½	3	6½	3	6½	2½	6½	2½	6	2½
Topgallant masts	Fore & main shrouds	4½	2½	4½	2½	4½	2	4	1¾	3½	1¾
	Mizen shrouds	4	1¾	4	1¾	3½	1¾	3½	1¾	3½	1¾
	Fore & main stays	5	2½	5½	2½	5½	2½	5½	2½	5½	2½
	Mizen stays	4½	2¼	4½	2¼	4½	2¼	4½	2¼	3½	2
	Fore & main backstays	5	2½	5½	2½	5½	2½	5½	2½	5½	2½
	Mizen backstays	4½	2¼	4½	2¼	4½	2¼	4½	2¼	4	2
Royal masts	Fore & main stays	4½	2	4	2	4	2	3½	1¾	3½	1¾
	Mizen stay	3½	1¾	3½	1¾	3½	1¾	3½	1½	3	1½
	Fore & main backstays	4½	2	4	2	4	2	3½	1¾	3½	1½
	Mizen backstays	3½	1¾	3½	1¾	3½	1¾	3½	1½	3	1½
Jib gear	Standing jib stay	7½	3¼	7½	3¼	7	3	7	3¼	6½	2¾
	Flying "	5	2½	5	2½	4½	2½	4½	2½	4½	2
	Standing guys	7½	3¼	7½	3¼	6½	3	7	3¼	6½	3
	Flying "	5	2½	5	2½	4½	2½	4½	2½	4½	2
	Martingale stay	7½	3¼	7½	3¼	7	3	6½	3¼	6½	2½
	Martingale back-ropes	5½	2½	5½	2½	5	2½	5	2½	4½	2½
	Bob-stays { of wire (single), of hemp (double) }	10½	4½	10½	4½	10	4	9½	3½	9½	3½
	Bowsprit shrouds	9½	4	9½	4¼	9	3¾	9	3½	8	3½
		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.	
Total wt. of hemp rigging		257 3 7		208 1 10		186 0 20		172 1 6		145 0 19	
" wire "		147 0 20		138 0 14		119 2 1		108 3 26		96 2 4	

	Species of Standing Rigging	1,000 Tons Girth (ins.) Hemp	Wire	800 Tons Girth (ins.) Hemp	Wire	600 Tons Girth (ins.) Hemp	Wire	350 Tons Girth (ins.) Hemp	Wire	200 Tons Girth (ins.) Hemp	Wire
Lower masts	Fore & main shrouds	9	4	9	3½	8½	3½	6½	2½	6	2½
	Mizen shrouds	6	3½	6	3½	5½	3½	4½	2½	4	2½
	Fore & main stays (dbl.)	9½	4½	9½	3½	9	4	6½	2½	6	2½
	Mizen stay (single)	6½	2¾	6½	2¾	6	2¾	5	2½	4½	2½
Topmasts	Fore & main shrouds	5½	2½	5	2½	4½	2	3½	1¾	3½	1½
	Mizen shrouds	4	1¾	4	1¾	3½	1¾	3½	1½	3½	1½
	Fore & main stays (dbl.)	8½	2½	8	2½	7	2½	6	2½	5½	2½
	Mizen stay (single)	5½	2½	5½	2½	5	2½	4½	2	4	1¾
	Fore & main backstays	8½	3	8	2½	7	2½	6	2½	4½	1½
	Mizen backstays	5½	2½	5½	2½	5	2½	4½	2	4	1½
Topgallant masts	Fore & main shrouds	3½	1¾	3½	1½	3½	1½	2½	1½	2½	1½
	Mizen shrouds	3½	1½	3	1½	3	1½	2½	1½	2	1
	Fore & main stays	5	2	4½	2	3½	1½	3½	1½	3	1½
	Mizen stays	4½	1½	3½	1½	3½	1½	3	1½	3½	1½
	Fore & main backstays	5	2	4½	2	4	1½	3½	1½	3½	1½
	Mizen backstays	4½	1½	3½	1½	3½	1½	3	1½	2½	1½
Royal masts	Fore & main stays	3½	1½	3½	1½	3	1½	2½	1½	2½	1
	Mizen stay	3½	1½	3½	1½	3	1½	2½	1½	1½	1
	Fore & main backstays	3½	1½	3½	1½	3½	1½	2½	1½	2½	1
	Mizen backstays	3½	1½	3½	1½	3	1½	2½	1½	2	1
Jib gear	Standing jib stay	6½	3	6	2½	5½	2½	5	2½	4½	2½
	Flying "	4	1¾	3½	1½	3½	1½	3½	2½	3	1½
	Standing guys	6	2½	6	2½	5½	2½	5	2½	4½	2½
	Flying "	4	1¾	4	1½	3½	1½	3½	1½	3	1½
	Martingale stay	6	2½	6	2½	5½	2½	5	2½	4½	2½
	Martingale back-ropes	4½	2½	4½	2½	4	1½	3½	1½	3½	1½
	Bob-stays { of wire (single), of hemp (double) }	9	3½	8½	3½	8	3½	—	3½	8	3½
	Bowsprit shrouds	8	3½	7½	3½	7	2½	4½	2½	5	2½
		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.		Cwt. Qr. Lb.	
Total wt. of hemp rigging		131 1 9		108 0 14		91 0 11		68 3 19		44 0 13½	
" wire "		90 1 1		79 2 6		63 1 7		35 1 6		27 2 2	

Wire rigging is now almost universally used for the standing rigging of ships, as its advantages over that of hemp are considerable, its bulk being about
t is reduced to nearly one-half; it does not stretch permanently under great
of length to which hemp is subject by change in the state of moisture of the
the rigging.

Table of the Dimensions of Ships' Blocks (in Inches).

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
Common Single-thick Blocks.													
3	2¼	1½	2¼	1¾	⅜	⅜	17	12¾	7¼	13	10½	2⅛	1¼
4	3¼	2	3⅛	2½	½	7/16	18	13½	7½	13⅝	11¼	2¼	1⅜
5	4	2⅜	3¾	3¼	⅝	½	19	14¼	8	14⅜	12	2⅜	1⅜
6	4¾	2⅞	4⅞	3¾	¾	9/16	20	14¾	8½	15⅛	12½	2½	1½
7	5½	3¼	5½	4½	⅞	⅝	21	15½	9	15¾	13	2⅝	1½
8	6¼	3⅝	6¼	5	1	11/16	22	16¼	9¼	16⅞	14	2¾	1⅝
9	7	4⅛	7¼	5¾	1⅛	¾	23	16½	9¾	17½	14½	2⅞	1⅝
10	7¾	4½	7⅞	6½	1¼	¾	24	17¼	10	18¼	18	3	1¾
11	8½	5	8½	7	1⅜	⅞	25	17¾	10½	19	15¾	3⅛	1⅞
12	9¼	5¼	9¼	7¾	1½	1	26	18¼	10¾	19⅝	16¼	3¼	1⅞
13	10¼	5¾	10	8¼	1⅝	1	27	19	11¼	20½	17	3⅜	2
14	10¾	6	10⅞	9	1¾	1⅛	28	19¾	11½	21⅜	17¾	3½	2
15	11¼	6½	11½	9½	1⅞	1⅛	29	20¼	11¾	22	18¼	3⅝	2
16	12¼	7	12⅛	10	2	1¼	30	21	12	22⅞	12	3¾	2
Common Single-thin Blocks.													
8	6¾	3¾	6⅜	5⅜	⅞	⅝	19	15	6¼	15	13¼	1⅝	1⅛
9	7½	3¾	7⅛	6	1	¾	20	15¾	6¾	16	14	1⅞	1¼
10	8¼	4⅛	8	6¾	1⅛	¾	21	16½	6¾	16½	14½	1⅞	1¼
11	9	4¼	8¾	7⅛	1⅛	⅞	22	17¼	6¾	17	15	1⅞	1¼
12	9¾	4¾	9⅝	8¼	1¼	⅞	23	18	6¾	17½	15½	1⅞	1¼
13	10½	5	10⅜	9	1¼	⅞	24	18¾	6¾	18¼	16¼	1⅞	1¼
14	11¼	5¼	11¼	9¾	1⅜	1	25	19½	7	19½	17½	1⅞	1¼
15	12	5½	12	10½	1⅜	1⅛	26	20¼	7	20½	18½	1⅞	1¼
16	12¾	5¾	12¾	11¼	1⅜	1⅛	27	21	7	21¼	19¼	1⅞	1¼
17	13½	6	13¾	12	1½	1⅛	28	21¾	7	22¼	20¼	1⅞	1¼
18	14¼	6	14½	12¾	1½	1⅛	—	—	—	—	—	—	—
Clump Blocks.													
5	3½	2⅞	3⅝	2¾	⅞	⅝	13	9	7¼	9¼	6¾	2½	1¼
6	4¼	3½	4⅛	3⅜	1	⅝	14	9½	8	10½	7¾	5¾	1⅜
7	4¾	4	5¼	4	1⅛	¾	15	10	8½	10¾	8	2¾	1⅜
8	5¾	5	6	4½	1½	⅞	16	10¼	8½	11¼	8¼	3	1½
9	6½	5¼	6⅛	4⅞	1⅝	⅞	17	10½	8¾	11½	8½	3	1½
10	7	5¾	7½	5¼	2	1	18	11	9	12	9	3	1½
11	7¼	6	7⅞	5¾	2⅛	1	19	11½	9½	12⅝	9½	3⅛	1⅝
12	8	6¾	8¾	6¼	2½	1¼	20	12	10	13⅛	10	3⅛	1⅝
Clewline Blocks.													
5	4¾	4½	—	2½	¾	½	8	7¾	7	—	4	1¼	¾
6	6	5½	—	3⅛	1	⅝	10	9½	8	—	4¾	1½	1
7	6¾	6½	—	3½	1⅛	¾	11	10¾	9	—	5½	1⅝	1

TABLE OF THE DIMENSIONS OF SHIPS' BLOCKS (in Inches)—continued.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Thickness of Partition	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Thickness of Partition	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
Double-thick Blocks.															
3	2 1/4	2 3/8	2 1/8	3/8	1 3/4	3/8	3/8	17	13	11 3/4	13	1 7/8	10 1/2	2 1/8	1 3/4
4	3 1/4	3	3 3/8	1/2	2 1/2	1/2	7/16	18	13 3/4	12 1/4	13 3/4	1 7/8	11 1/4	2 1/8	1 3/8
5	4	3 5/8	3 7/8	1/2	3 1/4	5/8	1/2	19	14 1/2	12 3/4	14 1/2	2	12	2 3/8	1 3/8
6	4 3/4	4 3/4	4 3/4	5/8	3 3/4	3/4	9/16	20	15 1/4	13 1/2	15 1/4	2 1/8	12 1/2	2 1/2	1 3/8
7	5 1/2	5	5 1/2	3/4	4 1/2	7/8	5/8	21	16	14 1/4	16	2 1/4	13	2 5/8	1 3/8
8	6 1/4	5 7/8	6 1/4	7/8	5	1	11/16	22	16 3/4	15	16 3/4	2 1/4	14	2 3/4	1 5/8
9	7	6 1/2	7	1	5 3/4	1 1/8	3/4	23	17 1/2	15 1/2	17 1/2	2 3/8	14 1/2	2 7/8	1 3/4
10	7 3/4	7	7 3/4	1 1/8	6 1/2	1 1/4	13/16	24	18 1/4	16	18 1/4	2 3/8	15	3	1 3/4
11	8 1/2	7 3/4	8 1/2	1 1/4	7	1 3/8	7/8	25	19	16 1/2	19	2 1/2	15 3/4	3 1/8	1 7/8
12	9 1/4	8 1/4	9 1/4	1 3/8	7 3/4	1 1/2	1	26	19 3/4	17	19 3/4	2 1/2	16 1/4	3 1/4	2
13	10	9	10	1 1/2	8 1/4	1 5/8	1 1/8	27	20 1/2	17 1/2	20 1/2	2 1/2	17	3 3/8	2
14	10 3/4	9 1/2	10 3/4	1 1/2	9	1 3/4	1 1/4	28	21 1/4	18	21 1/4	2 5/8	17 3/4	3 1/2	2 1/8
15	11 1/2	10 1/4	11 1/2	1 5/8	9 1/2	1 7/8	1 1/4	29	22	18 1/2	22	2 5/8	18 1/4	3 5/8	2 1/8
16	12 1/2	11	12 1/4	1 3/4	10	2	1 1/4	30	22 3/4	19	22 3/4	2 5/8	19	3 3/4	2 1/8
Double-thin Blocks.															
8	6 3/4	5 1/4	6 3/8	7/8	5 3/8	7/8	5/8	18	14 1/4	9 1/4	14 1/2	1 1/8	12 3/4	1 5/8	1 1/8
9	7 1/2	6	7 1/8	1	6	1	5/8	19	15	9 1/2	15	1 1/8	13 1/4	1 5/8	1 1/8
10	8 1/4	6 1/2	8	1 1/8	6 3/4	1 1/8	3/4	20	15 3/4	10 1/4	16	1 3/8	14	1 7/8	1 1/4
11	9	6 3/4	8 3/4	1 1/8	7 1/2	1 1/8	7/8	21	16 1/2	10 1/4	16 1/2	1 5/8	14 1/2	1 7/8	1 1/4
12	9 3/4	7	9 5/8	1 1/8	8 1/4	1 1/4	7/8	22	17 1/4	10 1/4	17	1 5/8	15	1 7/8	1 1/4
13	10 1/2	7 1/4	10 3/8	1 1/8	9	1 1/4	7/8	23	18	10 1/4	17 1/2	1 5/8	15 1/2	1 7/8	1 1/4
14	11 1/4	8	11 1/4	1 1/4	10 1/2	1 3/8	1 1/8	24	18 3/4	10 1/4	18 1/4	1 5/8	16 1/4	1 7/8	1 1/4
15	12	8 1/2	12	1 1/4	10 1/2	1 3/8	1 1/8	25	19 1/2	10 1/2	19 1/2	1 3/4	17 1/2	1 7/8	1 1/4
16	12 3/4	8 3/4	12 3/4	1 3/8	11 1/4	1 3/8	1 1/8	26	20 1/4	10 1/2	20 1/4	1 1/4	18 1/2	1 7/8	1 1/4
17	13 1/2	9 1/4	13 3/4	1 1/2	12	1 5/8	1 1/8	27	21	10 1/2	21 1/2	1 3/4	19 1/4	1 7/8	1 1/4
Treble-thick Blocks.															
3	2 1/4	3 1/8	2 1/8	3/8	1 3/4	3/8	3/8	17	13	15 1/2	13	1 7/8	10 1/2	2 1/8	1 3/8
4	3 1/4	4	3 1/8	1/2	2 1/2	1/2	1/2	18	13 3/4	16 3/4	13 3/4	1 7/8	11 1/4	2 1/4	1 3/8
5	4	5	3 7/8	1/2	3 1/4	5/8	1/2	19	14 1/2	17 3/4	14 1/2	2	12	2 3/8	1 3/8
6	4 3/4	6	4 3/4	5/8	3 3/4	3/4	1/2	20	15 1/4	18 3/4	15 1/4	2 1/8	12 1/8	2 1/2	1 5/8
7	5 1/2	7	5 1/2	3/4	4 1/2	7/8	5/8	21	16	19 3/4	16	2 1/4	13	2 5/8	1 5/8
8	6 1/4	7 3/4	6 1/4	7/8	5	1	5/8	22	16 3/4	20 1/4	16 3/4	2 1/4	14	2 3/4	1 5/8
9	7	8 3/4	7	1	5 3/4	1 1/8	3/4	23	17 1/2	21	17 1/2	2 3/8	14 1/2	2 7/8	1 3/4
10	7 3/4	9 3/4	7 3/4	1 1/8	6 1/2	1 1/4	7/8	24	18 1/4	21 3/4	18 1/4	2 3/8	15	3	1 3/4
11	8 1/2	10 3/4	8 1/2	1 1/4	7	1 3/8	1	25	19	22 1/4	19	2 1/2	15 3/4	3 1/8	1 7/8
12	9 1/4	11 1/4	9 1/4	1 3/8	7 3/4	1 1/2	1	26	19 3/4	23	19 3/4	2 1/2	16 1/4	3 1/4	2
13	10	12	10	1 1/2	8 1/4	1 5/8	1 1/8	27	20 1/2	23 1/2	20 1/2	2 1/2	17	3 3/8	2
14	10 3/4	13	10 3/4	1 1/2	9	1 3/4	1 1/4	28	21 1/4	24	21 1/4	2 5/8	17 3/4	3 1/2	2 1/8
15	11 1/2	13 3/4	11 1/2	1 5/8	9 1/2	1 7/8	1 1/4	29	22	24 1/2	22	2 5/8	18 1/4	3 5/8	2 1/8
16	12 1/4	14 3/4	12 1/2	1 3/4	10	2	1 1/4	30	22 3/4	25	22 3/4	2 5/8	19	3 3/4	2 1/8

Table of the Dimensions of Ships' Blocks (in Inches)—continued.

Long-tackle Blocks.

Length of Block	Breadth of Upper Block	Breadth of Lower Block	Thickness of Block	Diameter of Upper Sheave	Diameter of Lower Sheave	Thickness of Sheaves	Length of Upper Mortice	Length of Lower Mortice	Thickness of Mortice	Size of Pin-hole
10	$4\frac{7}{8}$	$3\frac{1}{2}$	3	$3\frac{7}{8}$	$2\frac{3}{4}$	$\frac{3}{4}$	$4\frac{3}{4}$	$3\frac{5}{8}$	$\frac{7}{8}$	$\frac{5}{8}$
11	$5\frac{1}{4}$	$3\frac{7}{8}$	$3\frac{1}{4}$	$4\frac{1}{4}$	3	$\frac{7}{8}$	$5\frac{1}{4}$	$3\frac{7}{8}$	1	$\frac{5}{8}$
12	$5\frac{7}{8}$	$4\frac{3}{8}$	$3\frac{1}{4}$	$4\frac{7}{8}$	3	$\frac{7}{8}$	$5\frac{7}{8}$	4	1	$\frac{5}{8}$
13	$6\frac{1}{2}$	5	$3\frac{1}{2}$	5	$3\frac{1}{2}$	$\frac{7}{8}$	$6\frac{1}{8}$	$4\frac{1}{2}$	1	$\frac{5}{8}$
14	$6\frac{3}{4}$	$5\frac{1}{4}$	$3\frac{1}{2}$	$5\frac{1}{2}$	4	$\frac{7}{8}$	$6\frac{1}{2}$	5	1	$\frac{5}{8}$
15	$7\frac{3}{8}$	$5\frac{5}{8}$	$3\frac{5}{8}$	$5\frac{7}{8}$	$4\frac{1}{8}$	1	$7\frac{1}{8}$	$5\frac{1}{4}$	$1\frac{1}{8}$	$\frac{3}{4}$
16	$7\frac{3}{4}$	6	4	$6\frac{1}{4}$	$4\frac{1}{4}$	$1\frac{1}{8}$	$7\frac{3}{8}$	$5\frac{1}{2}$	$1\frac{1}{4}$	$\frac{3}{4}$
17	$8\frac{1}{4}$	$6\frac{1}{4}$	4	$6\frac{1}{2}$	$4\frac{3}{8}$	$1\frac{1}{8}$	$7\frac{3}{4}$	$5\frac{5}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$
18	$8\frac{3}{4}$	$6\frac{1}{2}$	4	$7\frac{1}{4}$	$4\frac{5}{8}$	$1\frac{1}{8}$	$8\frac{1}{8}$	$5\frac{7}{8}$	$1\frac{1}{4}$	$\frac{3}{4}$
19	—	—	—	$7\frac{5}{8}$	5	$1\frac{1}{4}$	—	—	—	$\frac{13}{16}$
20	—	—	—	8	$5\frac{1}{2}$	$1\frac{1}{4}$	—	—	—	$\frac{13}{16}$
21	—	—	—	$8\frac{3}{4}$	$5\frac{3}{4}$	$1\frac{3}{8}$	—	—	—	$\frac{7}{8}$
22	—	—	—	9	$6\frac{1}{8}$	$1\frac{3}{8}$	—	—	—	$\frac{7}{8}$
23	—	—	—	$9\frac{1}{2}$	$6\frac{3}{8}$	$1\frac{1}{2}$	—	—	—	1
24	—	—	—	$10\frac{1}{8}$	$6\frac{3}{4}$	$1\frac{1}{2}$	—	—	—	1
25	—	—	—	$10\frac{3}{4}$	7	$1\frac{1}{2}$	—	—	—	1
26	—	—	—	11	$7\frac{1}{4}$	$1\frac{1}{2}$	—	—	—	1
27	$13\frac{1}{4}$	$9\frac{1}{8}$	$5\frac{1}{2}$	$11\frac{1}{4}$	$7\frac{1}{2}$	$1\frac{1}{2}$	$12\frac{7}{8}$	$9\frac{1}{8}$	$1\frac{5}{8}$	$1\frac{1}{8}$
28	$13\frac{1}{2}$	$9\frac{3}{4}$	$5\frac{3}{4}$	$11\frac{1}{2}$	$8\frac{1}{4}$	$1\frac{5}{8}$	$13\frac{1}{4}$	$9\frac{3}{8}$	$1\frac{3}{4}$	$1\frac{1}{8}$
29	—	—	—	$12\frac{1}{4}$	$8\frac{1}{4}$	$1\frac{5}{8}$	—	—	—	$1\frac{1}{4}$
30	—	—	—	$12\frac{1}{2}$	$8\frac{1}{2}$	$1\frac{3}{4}$	—	—	—	$1\frac{1}{4}$

Topsail-sheet Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Size of Pin-hole
6	$4\frac{3}{4}$	$2\frac{7}{8}$	$4\frac{5}{8}$	$3\frac{3}{4}$	$\frac{3}{4}$	$\frac{1}{2}$	13	10	$6\frac{1}{4}$	$10\frac{1}{4}$	$8\frac{1}{4}$	$1\frac{7}{8}$	$1\frac{1}{8}$
7	$5\frac{1}{2}$	$3\frac{1}{4}$	$5\frac{1}{8}$	$4\frac{1}{2}$	$\frac{7}{8}$	$\frac{5}{8}$	14	$10\frac{3}{4}$	$6\frac{7}{8}$	$10\frac{5}{8}$	$8\frac{1}{2}$	2	$1\frac{1}{4}$
8	$6\frac{1}{4}$	$3\frac{7}{8}$	$6\frac{1}{8}$	5	1	$\frac{5}{8}$	15	$11\frac{1}{2}$	$7\frac{1}{4}$	$11\frac{1}{4}$	9	$2\frac{1}{8}$	$1\frac{1}{4}$
9	7	$4\frac{1}{8}$	7	$5\frac{3}{4}$	$1\frac{1}{8}$	$\frac{3}{4}$	16	$12\frac{1}{4}$	$7\frac{5}{8}$	$11\frac{7}{8}$	$9\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{8}$
10	$7\frac{3}{4}$	$4\frac{1}{2}$	$7\frac{5}{8}$	$6\frac{1}{4}$	$1\frac{1}{4}$	$\frac{3}{4}$	17	13	$7\frac{7}{8}$	$12\frac{3}{8}$	10	$2\frac{3}{8}$	$1\frac{3}{8}$
11	$8\frac{1}{2}$	$5\frac{1}{4}$	$8\frac{1}{4}$	$6\frac{3}{4}$	$1\frac{3}{8}$	1	18	$13\frac{3}{4}$	$8\frac{1}{2}$	13	$10\frac{1}{4}$	$2\frac{1}{2}$	$1\frac{1}{2}$
12	$9\frac{1}{4}$	$5\frac{3}{4}$	$9\frac{3}{8}$	$7\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{8}$	—	—	—	—	—	—	—

Nine-pin Blocks.

Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Length of Pin	Length of Block	Breadth of Block	Thickness of Block	Length of Mortice	Diameter of Sheave	Thickness of Sheave	Length of Pin
8	$5\frac{1}{8}$	4	$6\frac{1}{4}$	$4\frac{1}{4}$	$1\frac{1}{8}$	$5\frac{1}{4}$	11	$6\frac{7}{8}$	5	$8\frac{1}{2}$	6	$1\frac{3}{8}$	$6\frac{1}{8}$
9	$5\frac{5}{8}$	$4\frac{1}{8}$	$6\frac{3}{4}$	$4\frac{1}{2}$	$1\frac{1}{4}$	$5\frac{1}{2}$	12	$7\frac{3}{4}$	$5\frac{1}{4}$	$9\frac{1}{2}$	$6\frac{3}{4}$	$1\frac{5}{8}$	7
10	$6\frac{1}{4}$	$4\frac{1}{2}$	$7\frac{1}{4}$	$5\frac{1}{4}$	$1\frac{1}{4}$	$5\frac{3}{4}$	—	—	—	—	—	—	—

SIZES AND TESTS OF WESTON'S DIFFERENTIAL PULLEY BLOCKS AND CHAIN.

Differential Pulley Blocks.

Description	Weight to be lifted in Tons	Tested to Weight in Tons
Upper pulley, with sprocket wheel *	4	6
Lower "	4	6
Upper " with sprocket wheel *	3	4½
Lower "	3	4½
Upper " with sprocket wheel *	2	3
Lower "	2	3
Upper "	1	1½
Lower "	1	1½
Upper "	½	¾
Lower "	½	¾
Upper "	¼	⅜
Lower "	¼	⅜

Chain for Ditto.

Diameter of Iron of Link	Length of Chain	Width of Link	Chain tested to	Block to Lift
Inches	Inches	Inches	Tons	Tons
⅝	3⅛	$1\frac{15}{16}$	4⅝	4
$\frac{9}{16}$	$2\frac{25}{32}$	1¾	3¾	3
$\frac{7}{16}$	$2\frac{1}{16}$	$1\frac{7}{16}$	2¼	2
$\frac{5}{16}$	$1\frac{17}{32}$	1	1⅛	1
¼	1¼	$\frac{25}{32}$	¾	½
$\frac{7}{32}$	$1\frac{3}{16}$	$\frac{23}{32}$	$\frac{23}{40}$	¼

* All sprocket wheels are to work with ¼-inch chain.

SIZES AND TESTS OF ENGINEERS' TACKLE BLOCKS, WROUGHT IRON WITH GUNMETAL SHEAVES.

Description	Weight of Blocks Complete		Weight to be Lifted	Diam. of Sheave	Finished Weight of Sheave		Size of Rope	Proof Strain to be borne without Injury	Description	Weight of Blocks Complete		Weight to be Lifted	Diam. of Sheave	Finished Weight of Sheave		Size of Rope	Proof Strain to be borne without Injury
	Lbs.	Oz.	Tons	Inches	Lbs.	Oz.	Inches	Tons		Lbs.	Oz.	Tons	Inches	Lbs.	Oz.	Inches	Tons
Double	382	0	20	$14\frac{3}{4}$	47	13	$7\frac{1}{2}$	30	Treble	470	0	20	$14\frac{3}{4}$	48	11	$7\frac{1}{2}$	30
„	177	0	11	$11\frac{1}{4}$	26	5	$4\frac{3}{4}$	18	„	217	0	11	$11\frac{1}{4}$	26	5	$4\frac{3}{4}$	18
„	79	0	8	$8\frac{3}{8}$	13	13	4	12	„	98	8	8	$8\frac{3}{8}$	13	13	4	12
„	63	0	6	$7\frac{5}{8}$	10	6	$3\frac{1}{2}$	9	„	78	0	6	$7\frac{5}{8}$	10	5	$3\frac{1}{2}$	9
„	39	8	4	$6\frac{1}{16}$	6	5	$3\frac{1}{4}$	6	„	48	0	4	$6\frac{1}{16}$	6	2	$3\frac{1}{4}$	6
„	21	12	$2\frac{1}{2}$	$4\frac{7}{8}$	3	$2\frac{1}{2}$	3	$3\frac{3}{4}$	„	26	8	$2\frac{1}{2}$	$4\frac{7}{8}$	3	6	3	$3\frac{3}{4}$
„	14	12	$1\frac{1}{2}$	$4\frac{1}{4}$	2	6	$2\frac{1}{2}$	$2\frac{1}{4}$	„	18	8	$1\frac{1}{2}$	$4\frac{1}{4}$	2	4	$2\frac{1}{2}$	$2\frac{1}{4}$
„	10	0	1	$3\frac{3}{4}$	1	$8\frac{1}{2}$	2	$1\frac{1}{2}$	„	12	8	1	$3\frac{3}{4}$	1	9	2	$1\frac{1}{2}$

GALVANISED BLOCKS FOR DERRICKS WITH GUNMETAL SHEAVES.

Description	Size of Block	Weight of Block Complete		Gunmetal Sheave				Diameter of Pin	Proof Strain of Block
				Thickness	Diameter	Finished Weight			
	Ins.	Lbs.	Ozs.	Ins.	Ins.	Lbs.	Ozs.	Ins.	Tons
. iron shell	6	5	10	1	$2\frac{7}{8}$		$13\frac{1}{2}$	$\frac{3}{4}$	1
. ckle with fittings	$7\frac{1}{2}$	18	6	$1\frac{1}{16}$	$3\frac{7}{8}$	1	6	$\frac{7}{8}$	$2\frac{1}{2}$
.	$7\frac{1}{2}$	21	7	$1\frac{1}{16}$	$3\frac{7}{8}$	1	6	$\frac{7}{8}$	$2\frac{1}{2}$
iron shell and wrought iron fittings	6	6	1	$1\frac{1}{16}$	$3\frac{1}{16}$	1	2	$\frac{3}{4}$	$1\frac{1}{2}$

WROUGHT IRON BLOCKS FOR TORPEDO NET DEFENCE, WITH CAST STEEL SHEAVES.

Description	Size of Block	Weight of Block Complete	Cast Steel Sheaves		Diameter of Pin	Swivel Eye			Proof Strain
			Thickness	Diameter		Size in Clear	Diameter of Iron	Diameter of Hole	
	Ins.	Lbs.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Tons
Blocks.—Wrought iron with swivel eye and cast rope	$22\frac{1}{2}$	118	$2\frac{7}{16}$	$18\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{3}{4}\times3\frac{1}{2}$	$1\frac{5}{8}$	2	18
.	—	—	$2\frac{7}{16}$	$18\frac{1}{2}$	—	—	—	—	18
d cast rope	$17\frac{1}{2}$	$61\frac{1}{2}$	$1\frac{7}{16}$	13	$1\frac{1}{2}$	$4\frac{3}{4}\times2\frac{1}{2}$	$4\frac{1}{2}$	$1\frac{1}{2}$	12
Sheaves.—Cast steel spar for above blocks . .	—	—	$1\frac{7}{16}$	13	—	—	—	—	12

Note.—The blocks in the above table to be of best wrought iron, except the guide plates, which are to be of open-hearth steel. The sheaves to be steel castings of the usual Admiralty quality,* bushed with phosphor bronze, the groove for taking the rope to be machined.

* The Admiralty tests for cast steel sheaves are as follows:—1st, minimum tensile stress per square inch, 26 tons; 2nd, minimum elongation in 8 inches, 10 per cent.; 3rd, minimum bending cold 1 inch diameter or a rectangular section as near to this area as possible, 90°; 4th, each casting to fall upon hard ground from a height of 10′ 0″.

Single Wrought Iron Lift Blocks with Padlock Shackles and Gunmetal Sheaves

Size of Block	Weight of Block complete	Flexible Steel Wire Rope: Size to Reeve	Flexible Steel Wire Rope: Breaking Strain	Flexible Steel Wire Rope: Diameter when served	Gunmetal Sheave: Thickness	Gunmetal Sheave: Diameter	Gunmetal Sheave: Finished Weight	Diameter of Pin	Shackle: Diameter of Iron	Shackle: Size in clear	Shackle: Bolts: Diameter of Oval	Shackle: Bolts: Diameter of Round	Shackle: Lug	Proof Strain of Block
ins.	lbs. oz.	ins.	tons	ins.	ins.	ins.	lbs. oz.	ins.	ins.	ins.	ins.	ins.	ins.	tons
6¾	7 8	1½ 1¾	4 5½	⅝ ¾	⅞	5	2 7	¾	⅝	1⅛ × 1½	¾ × ⅜	9/16	9/32 × ¾	3
9	18 8	2 2¼	7 9	⅞ 1	1⅛	7	5 8	1	⅞	1½ × 2	1 × ½	⅝	⅜ × 1	5
12	39 8	2½ 3	11¾ 17	1⅛ 1¼	1⅜	9	12 6	1¼	1⅛	2 × 2½	1¼ × ⅝	1	½ × 1¼	9
15	79 8	3½ 4	24 31	1⅜ 1⅝	1¾	11½	23 8	1⅝	1 7/16	2½ × 3¼	1⅝ × 13/16	1¼	⅝ × 1½	15
18	131 0	4½ 5	39 59	1¾ 2	2¼	14	35 4	[illegible]	1¾	3½ × 4½	2 × 1	1½	¾ × 2	29

Wrought Iron Snatch Blocks with Gunmetal Sheaves

Weight of Block complete	Weight to be Lifted	Size of Block: Across the Sheave	Size of Block: Length of Shell in direction of Strap	Gunmetal Sheaves: Thickness	Gunmetal Sheaves: Diameter	Gunmetal Sheaves: Finished Weight	Diameter of Pin	Proof Strain of Blocks
lbs. oz.	tons	ins.	ins.	ins.	ins.	lbs. oz.	ins.	tons
55 8	6	8½	16	1¾	7¾	12 9	1⅜	9
37 8	4	7½	14½	1⅜	7⅛	7 12	1⅛	6
25 0	2½	6½	13	1¼	6½	6 1	1	5

Miscellaneous Wrought Iron Blocks with Gunmetal Sheaves

Description	Size of Block	Weight of Block complete	Gunmetal Sheave			Diameter of Pin	Oval Hook			Tests	
			Thickness	Diameter	Finished Weight		Size of Iron	Length	Opening	Working Load	Test Load
	Ins.	Lbs. Oz.	Ins.	Ins.	Lbs. Oz.	Ins.	Ins	Ins.	Ins.	Tons	Tons
Blocks with swivel hook, single	5	3 9	$\frac{11}{16}$	$2\frac{11}{16}$	— $12\frac{3}{4}$	$\frac{1}{2}$	$1\frac{1}{16} \times \frac{13}{16}$	$3\frac{3}{8}$	1	$\frac{1}{2}$	$\frac{3}{4}$
Ditto	7	7 0	$1\frac{3}{8}$	$3\frac{1}{2}$	2 2	$\frac{3}{4}$	$1\frac{3}{16} \times 1$	$3\frac{3}{4}$	$1\frac{5}{16}$	$\frac{5}{16}$	$1\frac{1}{4}$
Blocks with swivel hook, double, with cross bar at head becket and belaying pin	6	7 $12\frac{1}{2}$	$\frac{13}{16}$	$3\frac{1}{2}$	— 14	$\frac{5}{8}$	$1\frac{3}{16} \times 1$	$3\frac{3}{4}$	$1\frac{3}{16}$	1	$1\frac{1}{2}$
Blocks with swivel hook, treble, with cross bar at head without becket	6	9 3	$\frac{13}{16}$	$3\frac{1}{2}$	— 13	$\frac{5}{8}$	$1\frac{3}{16} \times 1$	$3\frac{3}{4}$	$1\frac{3}{16}$	1	$1\frac{1}{2}$
Blocks, single, for training tackles, with becket and thimbles	7	8 $7\frac{1}{2}$	$1\frac{1}{8}$	$3\frac{13}{16}$	1 13	$\frac{7}{8}$	$1\frac{3}{8} \times 1\frac{1}{8}$	$4\frac{1}{2}$	$1\frac{9}{16}$	2	3
Blocks, single, for training tackles, without becket	7	8 0	$1\frac{1}{8}$	$3\frac{13}{16}$	1 13	$\frac{7}{8}$	$1\frac{3}{8} \times 1\frac{1}{8}$	$4\frac{1}{2}$	$1\frac{9}{16}$	2	3

Table of Weight and Strength of Government Hawser Laid Cordage

Size of Yarn	Size of Rope in Ins.	Threads in ropes	Approximate Weight of Tarred per coil of 113 Fathoms			Breaking Strain		Approximate Weight of White per coil of 113 Fathoms			Breaking Strain	
			cwt.	qrs.	lbs.	tons	cwt.	cwt.	qrs.	lbs.	tons	cwt.
40 Thread Yarn Hemp. Tarred-Riga White-Italian	½	6	—	—	12½	—	3	—	—	10½	—	4½
	¾	12	—	—	25	—	6	—	—	21	—	9
	1	15	—	1	3½	—	8	—	—	26½	—	12
	1¼	21	—	1	14	—	10	—	1	7	—	15
	1½	33	—	2	11	—	15	—	2	—	1	1
	1¾	42	—	3	1	1	—	—	2	15	1	8
	2	54	—	3	25	1	7	—	3	7	1	17
	2¼	66	1	—	21	1	14	—	—	—	—	—
	2½	84	1	2	1	2	—	1	1	1	2	18
	2¾	102	1	3	9	2	10	—	—	—	—	—
	3	120	2	—	17	3	—	1	3	5	4	4
30 Thread Yarn Hemp. Tarred-Riga White-Italian	3¼	105	2	2	1	3	10	—	—	—	—	—
	3½	123	2	3	21	3	18	2	1	22	5	12
	4	159	3	3	5	5	—	3	—	18	7	5
	4½	201	4	3	5	6	9	4	—	—	9	5
	5	249	5	3	21	7	18	4	3	22	11	10
	6	360	8	2	9	11	10	7	—	17	16	10
25 Thread Yarn Hemp. Tarred-Petersburg White-Italian	6½	351	10	—	4	12	16	—	—	—	—	—
	7	408	11	2	18	14	16	9	2	25	20	—
	7½	468	—	—	—	—	—	11	—	17	23	—
	8	534	15	1	1	19	8	12	2	25	26	—
	9	675	19	1	5	24	—	16	—	9	33	—
	12	1,200	—	—	—	—	—	28	2	9	58	10
	16	—	—	—	—	—	—	—	—	—	110	—

Table of Weight and Strength of Government Coir Rope (3 Strand)

Size of Rope in Ins.	Weight of coil of 113 Fathoms			Breaking Strain		Size of Rope in Ins.	Weight of coil of 113 Fathoms			Breaking Strain	
	cwt.	qrs.	lbs.	tons	cwt.		cwt.	qrs.	lbs.	tons	cwt.
2½	—	2	11	—	9½	6	3	1	21	2	17
3	—	3	12	—	14	7	4	2	19	3	16
3½	1	—	19	—	18¼	8	6	0	11	4	17
4	1	2	2	1	5½	9	7	2	24	6	8
5	2	1	14	2	—	—	—	—	—	—	—

TABLE OF WEIGHT AND STRENGTH OF GOVERNMENT MANILLA HAWSER

Manilla Hawser, 3 *Strands*. *In Coils of* 122 *Fathoms each.*

Size of Yarn	Size of Rope in Ins.	Threads in Ropes	Approximate Weight of White			Breaking Strain		Approximate Weight of Tarred			Breaking Strain	
			Cwt.	Qrs.	Lbs.	Tons	Owt.	Cwt.	Qrs.	Lbs.	Tons	Owt.
40 Thread	1	15	—	—	27	—	13	—	1	3	—	11½
	1½	33	—	2	0	1	3	—	2	8	1	1
	2	54	—	3	7	2	0	—	3	20	1	16
	2½	84	1	1	1	3	0	1	1	21	2	18
	3	120	1	3	5	4	12	2	0	6	4	4
30 Thread	3½	123	2	1	22	6	3	2	3	6	5	12
	4	159	3	0	18	7	19	3	2	12	7	5
	4½	201	4	0	0	9	13	4	2	8	9	5
	5	249	4	3	22	12	13	5	2	18	11	10
	5½	303	6	0	2	15	5	6	3	14	13	15
	6	360	7	0	17	18	0	8	0	19	16	10

Manilla Hawser, 4 *Strands*. *In Coils of* 113 *Fathoms each.*

Size of Yarn	Size of Rope in Inches	Threads in Strand	Threads in Heart	Total Threads in Rope	Approximate Weight of White			Breaking Strain		Approximate Weight of Tarred			Breaking Strain	
					Cwt.	Qrs.	Lbs.	Tons	Cwt.	Cwt.	Qrs.	Lbs.	Tons	Owt.
40 Thread	1	3	2	14	—	—	24	—	10	—	—	27½	—	9
	1½	7	4	32	—	1	25	1	1	—	2	4½	—	18
	2	12	5	53	—	3	4	1	16	—	3	16½	1	13
	2½	20	7	87	1	1	4	2	14	1	1	24½	2	9
	3	28	10	122	1	3	6	4	3	2	0	7	3	15
30 Thread	3½	29	9	125	2	1	25	5	11	2	3	8	5	0
	4	37	12	160	3	0	17	7	3	3	2	11½	6	9
	4½	47	15	203	4	0	0	8	14	4	2	8	7	17
	5	58	21	253	4	3	25	11	8	5	2	20½	9	18
	5½	71	24	308	6	0	7	13	15	6	3	20	12	8
	6	84	30	366	7	0	21	16	4	8	0	24	14	12

Table of Weight and Strength of Government Cordage (Various).

Size of Rope	No. of Threads in Rope	Description of Rope	Length of Coil	Weight per Coil			Breaking Strain	
Ins.			Fathoms	Cwt.	Qrs.	Lbs.	Tons	Cwt.
2	36	Lasso	102	—	2	24	1	10
1¼	27	Signal halyard . .	122	—	1	7	1	3
1½	9	White packing—Russian hemp	280	1	0	0	—	—
1¾	12	White packing—Russian hemp	200	1	0	0	—	—
2	15	White packing—Russian hemp	155	1	0	0	—	—
—	—	White spun yard (flax), 5 thread	280	—	2	0	—	—
—	—	Hambro' Line (Russian hemp), 3 strand 12 thread	20	—	—	3	—	—
—	—	White deep-sea line, cable laid, 3 strand 9 thread	42	—	—	9½	—	—
—	—	Large, 3 strand 6 thread	196	—	1	0	—	—
—	—	Small, 3 thread . .	280	—	1	0	—	—

Table of Weight and Strength of Government Bolt Rope Cordage.

Size of Yarn	Size of Rope in Inches	Threads in Rope	Approximate weight of Tarred per Coil of 122 Fathoms			Breaking Strain		Approximate weight of White per Coil of 122 Fathoms			Breaking Strain	
			Cwt.	Qrs.	Lbs.	Tons	Cwt.	Cwt.	Qrs.	Lbs.	Tons	Cwt.
40 thread Italian hemp	½	6	—	—	12½	—	3¾	—	—	—	—	—
	¾	12	—	—	25	—	7½	—	—	—	—	—
	1	15	—	1	3½	—	9½	—	—	—	—	—
	1¼	21	—	1	14	—	12½	—	1	7	—	15
	1½	33	—	2	11	—	19	—	2	0	1	2
	1¾	42	—	3	1	1	3	—	2	15	1	10
	2	54	—	3	25	1	10	—	3	7	1	17
	2¼	66	1	0	21	1	18	—	3	27	2	7
	2½	84	1	2	1	2	10	1	1	1	2	18
	2¾	102	1	3	9	3	0	—	—	—	—	—
	3	120	2	0	17	3	10	1	3	5	4	8
30 thread Italian hemp	3¼	105	2	2	1	4	0	—	—	—	—	—
	3½	123	2	3	21	4	12	2	1	22	5	11
	4	159	3	3	5	6	0	3	0	18	7	5
	4½	201	4	3	5	7	12	—	—	—	—	—
	5	249	5	3	21	9	0	4	3	22	11	7
	7	489	11	2	17	18	10	—	—	—	—	—
	8	639	15	0	25	24	0	—	—	—	—	—

Sizes of Crane Hooks.

Fig. 315.

Table of Dimensions of Crane Hooks (Fig. 315).								
Tons	A	B	C	D	E	F	G	H
$\frac{1}{2}$	$3\frac{13}{16}$	$2\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{4}$	1	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{16}$
$\frac{3}{4}$	$4\frac{1}{8}$	$2\frac{1}{2}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{13}{16}$	$\frac{13}{16}$	[illegible]
1	$4\frac{1}{8}$	$2\frac{11}{16}$	$1\frac{5}{8}$	$1\frac{5}{16}$	$1\frac{1}{8}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{5}{16}$
$1\frac{1}{2}$	$4\frac{7}{8}$	$2\frac{13}{16}$	$1\frac{5}{8}$	$1\frac{5}{16}$	$1\frac{3}{16}$	1	$\frac{7}{8}$	$\frac{3}{8}$
2	$5\frac{1}{4}$	3	2	$1\frac{3}{8}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{15}{16}$	$\frac{7}{16}$
3	$5\frac{5}{8}$	$3\frac{1}{8}$	$2\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{16}$	$1\frac{1}{8}$	1	$\frac{1}{2}$
4	$5\frac{15}{16}$	$3\frac{5}{16}$	$2\frac{5}{16}$	$1\frac{7}{16}$	$1\frac{3}{8}$	$1\frac{3}{16}$	1	$\frac{9}{16}$
5	$6\frac{5}{16}$	$3\frac{7}{16}$	$2\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{7}{16}$	$1\frac{1}{4}$	$1\frac{1}{16}$	$\frac{5}{8}$
[illegible]	$6\frac{21}{32}$	$3\frac{5}{8}$	$2\frac{11}{16}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{1}{8}$	$\frac{11}{16}$
[illegible]	$7\frac{3}{8}$	$3\frac{15}{16}$	3	$1\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$\frac{11}{16}$
10	$8\frac{1}{8}$	$4\frac{1}{4}$	$3\frac{5}{16}$	$1\frac{3}{4}$	$1\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{3}{8}$	$\frac{3}{4}$
12	$8\frac{27}{32}$	$4\frac{9}{16}$	$3\frac{5}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{13}{16}$	$1\frac{7}{16}$	$\frac{3}{4}$
15	$9\frac{9}{16}$	$4\frac{7}{8}$	$3\frac{7}{8}$	$1\frac{15}{16}$	2	$1\frac{15}{16}$	$1\frac{9}{16}$	$\frac{13}{16}$
18	$10\frac{1}{4}$	$5\frac{3}{16}$	$4\frac{3}{16}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$2\frac{1}{8}$	$1\frac{5}{8}$	$\frac{13}{16}$
21	11	$5\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$	$\frac{7}{8}$

Lloyd's Sizes and Scantlings for Yards and Topmasts

YARDS

Length Cleated	Centre			1st Quarter			2nd Quarter			3rd Quarter		
	Diameter	Thickness		Diameter	Thickness		Diameter	Thickness		Diameter	Thickness	
		Iron	Steel		Iron	Steel		Iron	Steel		Iron	Steel
Feet	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
32	8	$\frac{3}{16}$	$\frac{3}{16}$	$7\frac{7}{8}$	$\frac{3}{16}$	$\frac{3}{16}$	$7\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	6	$\frac{3}{16}$	$\frac{3}{16}$
36	9	$\frac{3}{16}$	$\frac{3}{16}$	$8\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$8\frac{1}{8}$	$\frac{3}{16}$	$\frac{3}{16}$	$6\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$
40	10	$\frac{3}{16}$	$\frac{3}{16}$	$9\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	9	$\frac{3}{16}$	$\frac{3}{16}$	$7\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$
44	11	$\frac{3}{16}$	$\frac{3}{16}$	$10\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	10	$\frac{3}{16}$	$\frac{3}{16}$	$8\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$
48	12	$\frac{4}{16}$	$\frac{5}{20}$	$11\frac{3}{4}$	$\frac{4}{16}$	$\frac{5}{20}$	$10\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	9	$\frac{3}{16}$	$\frac{3}{16}$
52	13	$\frac{4}{16}$	$\frac{5}{20}$	$12\frac{5}{8}$	$\frac{4}{16}$	$\frac{5}{20}$	$11\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$	$9\frac{3}{4}$	$\frac{3}{16}$	$\frac{3}{16}$
56	14	$\frac{4}{16}$	$\frac{5}{20}$	$13\frac{5}{8}$	$\frac{4}{16}$	$\frac{5}{20}$	$12\frac{5}{8}$	$\frac{4}{16}$	$\frac{5}{20}$	$10\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$
60	15	$\frac{4}{16}$	$\frac{5}{20}$	$14\frac{5}{8}$	$\frac{4}{16}$	$\frac{5}{20}$	$13\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	$11\frac{1}{4}$	$\frac{3}{16}$	$\frac{3}{16}$
64	16	$\frac{5}{16}$	$\frac{6}{20}$	$15\frac{5}{8}$	$\frac{5}{16}$	$\frac{6}{20}$	$14\frac{3}{8}$	$\frac{5}{16}$	$\frac{6}{20}$	12	$\frac{4}{16}$	$\frac{5}{20}$
68	17	$\frac{5}{16}$	$\frac{6}{20}$	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	$15\frac{1}{4}$	$\frac{5}{16}$	$\frac{6}{20}$	$12\frac{3}{4}$	$\frac{4}{16}$	$\frac{5}{20}$
72	18	$\frac{5}{16}$	$\frac{6}{20}$	$17\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	$16\frac{1}{4}$	$\frac{5}{16}$	$\frac{6}{20}$	$13\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$
76	19	$\frac{6}{16}$	$\frac{7}{20}$	$18\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	$17\frac{1}{8}$	$\frac{5}{16}$	$\frac{6}{20}$	$14\frac{1}{4}$	$\frac{4}{16}$	$\frac{5}{20}$
80	20	$\frac{6}{16}$	$\frac{7}{20}$	$19\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	18	$\frac{5}{16}$	$\frac{6}{20}$	15	$\frac{4}{16}$	$\frac{5}{20}$
84	21	$\frac{7}{16}$	$\frac{8}{20}$	$20\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	19	$\frac{5}{16}$	$\frac{6}{20}$	$15\frac{3}{4}$	$\frac{5}{16}$	$\frac{6}{20}$
88	22	$\frac{7}{16}$	$\frac{8}{20}$	$21\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$19\frac{3}{4}$	$\frac{5}{16}$	$\frac{6}{20}$	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$
92	23	$\frac{7}{16}$	$\frac{8}{20}$	$22\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$20\frac{3}{4}$	$\frac{6}{16}$	$\frac{7}{20}$	$17\frac{1}{4}$	$\frac{5}{16}$	$\frac{6}{20}$
96	24	$\frac{7}{16}$	$\frac{8}{20}$	$23\frac{3}{8}$	$\frac{6}{16}$	$\frac{7}{20}$	$21\frac{5}{8}$	$\frac{6}{16}$	$\frac{7}{20}$	18	$\frac{5}{16}$	$\frac{6}{20}$

TOPMASTS.—The plating should be of the thickness given in the table. The seams of topmasts may be single riveted; the butts should be treble riveted, and their straps $\frac{1}{16}$ of an inch thicker in iron topmasts, and $\frac{1}{20}$ thicker in steel than the plates they connect. There should be doubling plates in the way of the lower mast cap. Topmasts should be efficiently strengthened in the way of the fid holes and in the way of sheave holes where such are cut, by the doubling plates, iron hoops, or by other approved methods.

LOWER YARDS.—The plating should be of the thickness given in the table. The seams of yards may be single riveted; their

OF SAILING VESSELS AND FULL-RIGGED STEAM VESSELS.

YARDS			TOPMASTS									
ENDS AT CLEATS			LENGTH	HEEL			Lower Part of Head			HEAD		
Diameter	Thickness			Diameter	Thickness		Diameter	Thickness		Diameter	Thickness	
	Iron	Steel			Iron	Steel		Iron	Steel		Iron	Steel
Ins.	Ins.	Ins.	Feet	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
4	$\frac{2}{16}$	$\frac{2}{16}$	32	12	$\frac{4}{16}$	$\frac{5}{20}$	$10\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	9	$\frac{3}{16}$	$\frac{3}{16}$
$4\frac{1}{2}$	$\frac{2}{16}$	$\frac{2}{16}$	34	$12\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	11	$\frac{4}{16}$	$\frac{5}{20}$	$9\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$
5	$\frac{2}{16}$	$\frac{2}{16}$	36	13	$\frac{4}{16}$	$\frac{5}{20}$	$11\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	10	$\frac{3}{16}$	$\frac{3}{16}$
$5\frac{1}{2}$	$\frac{2}{16}$	$\frac{2}{16}$	38	14	$\frac{4}{16}$	$\frac{5}{20}$	$12\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	$10\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$
6	$\frac{2}{16}$	$\frac{2}{16}$	40	$14\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	13	$\frac{4}{16}$	$\frac{5}{20}$	11	$\frac{3}{16}$	$\frac{3}{16}$
$6\frac{1}{2}$	$\frac{2}{16}$	$\frac{2}{16}$	42	15	$\frac{5}{16}$	$\frac{6}{20}$	$13\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	$11\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$
7	$\frac{2}{16}$	$\frac{2}{16}$	44	16	$\frac{5}{16}$	$\frac{6}{20}$	14	$\frac{4}{16}$	$\frac{5}{20}$	12	$\frac{4}{16}$	$\frac{5}{20}$
$7\frac{1}{2}$	$\frac{2}{16}$	$\frac{2}{16}$	46	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	$14\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	$12\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$
8	$\frac{3}{16}$	$\frac{3}{16}$	48	17	$\frac{6}{16}$	$\frac{7}{20}$	15	$\frac{5}{16}$	$\frac{6}{20}$	13	$\frac{5}{16}$	$\frac{6}{20}$
$8\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$	50	18	$\frac{6}{16}$	$\frac{7}{20}$	16	$\frac{5}{16}$	$\frac{6}{20}$	$13\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$
9	$\frac{3}{16}$	$\frac{3}{16}$	52	$18\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	14	$\frac{5}{16}$	$\frac{6}{20}$
$9\frac{1}{2}$	$\frac{3}{16}$	$\frac{3}{16}$	54	19	$\frac{6}{16}$	$\frac{7}{20}$	17	$\frac{5}{16}$	$\frac{6}{20}$	$14\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$
10	$\frac{3}{16}$	$\frac{3}{16}$	56	20	$\frac{6}{16}$	$\frac{7}{20}$	18	$\frac{5}{16}$	$\frac{6}{20}$	15	$\frac{5}{16}$	$\frac{6}{20}$
$10\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	58	$20\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$18\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	$15\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$
11	$\frac{4}{16}$	$\frac{5}{20}$	60	21	$\frac{6}{16}$	$\frac{7}{20}$	19	$\frac{5}{16}$	$\frac{6}{20}$	16	$\frac{5}{16}$	$\frac{6}{20}$
$11\frac{1}{2}$	$\frac{4}{16}$	$\frac{5}{20}$	62	22	$\frac{6}{16}$	$\frac{7}{20}$	20	$\frac{5}{16}$	$\frac{6}{20}$	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$
12	$\frac{4}{16}$	$\frac{5}{20}$	64	23	$\frac{6}{16}$	$\frac{7}{20}$	21	$\frac{5}{16}$	$\frac{6}{20}$	17	$\frac{5}{16}$	$\frac{6}{20}$

butts should be treble riveted, and connected by being overlapped, or by efficient butt straps. The plates should be doubled at the centre, and the doubling plates should extend beyond the truss hoops.

Where iron or steel masts and yards are to be constructed otherwise than in accordance with the tables, plans and particulars of the same must be submitted for the approval of the Committee.

Where steamers are intended to be fitted with topmasts for auxiliary purposes, they might be one-eighth less in diameter than prescribed by table.

LLOYD'S TABLE OF SIZES FOR THE STEEL

Register Tonnage under Deck	Tons 3,000 and under 3,500		Tons 2,600 and under 3,000		Tons 2,300 and under 2,600		Tons 2,000 and under 2,300	
Plating Number	32,000 and under 36,000		29,000 and under 32,000		26,600 and under 29,000		24,200 and under 26,600	
	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.
Fore & Main Shrouds . .	6 and 2 cap	$5\frac{1}{2}$	6 and 2 cap	$5\frac{1}{4}$	6 and cap	5	6 and cap	$4\frac{7}{8}$
„ „ Chain plates .		$2\frac{3}{4}$		$2\frac{5}{8}$		$2\frac{1}{2}$		$2\frac{3}{8}$
„ „ Dead-eyes . .		—		—		—		—
„ „ Lanyards (hemp)		—		—		—		—
„ „ Rigging Screws (Diameter at bottom of thread)		$2\frac{1}{4}$		$2\frac{1}{8}$		2		$1\frac{7}{8}$
„ „ Rigging Screws (Diameter of Pins)		2		$1\frac{7}{8}$		$1\frac{3}{4}$		$1\frac{5}{8}$
„ „ Topmst. bckstys.	3	$5\frac{1}{2}$	3	$6\frac{1}{4}$	3	5	3	$4\frac{7}{8}$
„ „ Top-gllt. bckstys.	2	$4\frac{1}{4}$	2	$4\frac{1}{8}$	2	$3\frac{7}{8}$	2	$3\frac{3}{4}$
„ „ Lower stays .	2	$5\frac{1}{2}$	2	$5\frac{1}{4}$	2	5	2	$4\frac{7}{8}$
„ „ Topmast stays .	2	$5\frac{1}{2}$	2	$5\frac{1}{4}$	2	5	2	$4\frac{7}{8}$
„ „ Top-gllt. stays .		$4\frac{1}{4}$		$4\frac{1}{8}$		$3\frac{7}{8}$		$3\frac{3}{4}$
Mizen Shrouds . . .	5 and cap	$4\frac{1}{2}$	5 and cap	$4\frac{3}{8}$	5 and cap	$4\frac{1}{4}$	5 and cap	$4\frac{1}{8}$
„ Topmast backstays .	3	$4\frac{1}{2}$	3	$4\frac{3}{8}$	3	$4\frac{1}{4}$	3	$4\frac{1}{8}$
„ Top-gallant backstays	2	$3\frac{1}{4}$	2	$3\frac{1}{8}$	2	3	2	$2\frac{7}{8}$
„ Lower stays . . .	2	$4\frac{1}{2}$	2	$4\frac{3}{8}$	2	$4\frac{1}{4}$	2	$4\frac{1}{8}$
„ Topmast stays . .	2	$4\frac{1}{2}$	2	$4\frac{3}{8}$	2	$4\frac{1}{4}$	2	$4\frac{1}{8}$
„ Top-gallant stays .		$3\frac{1}{4}$		$3\frac{1}{8}$		3		$2\frac{7}{8}$
Bobstay Bar		$4\frac{1}{8}$		$4\frac{1}{8}$		4		$3\frac{7}{8}$
„ Pin		$3\frac{1}{8}$		$3\frac{1}{8}$		3		$2\frac{7}{8}$
„ Chain . . .		$2\frac{1}{16}$		$2\frac{1}{16}$		2		$1\frac{15}{16}$
Bowsprit Shrouds (Chain) .	2	$1\frac{1}{8}$	2	$1\frac{1}{8}$	2	$1\frac{1}{16}$	2	$1\frac{1}{16}$

1. The above requirements are intended to apply to vessels in which the dimensions of the masts and yards are such as would not be deemed unusual for vessels of the respective tonnages; where these dimensions are extreme, or in other exceptional cases where deviations from the above sizes are required, rigging plans showing the sizes and arrangements of the several parts should be submitted for the approval of the Committee.

2. Where four masts are adopted instead of three, the tonnage of the vessel may be reduced one-fifth, and where five masts are adopted, one-fourth, in obtaining the sizes of rigging, &c., from the above table.

WIRE STANDING RIGGING, ETC., OF SAILING SHIPS.

Tons 1,800 and under 2,000		Tons 1,600 and under 1,800		Tons 1,400 and under 1,600		Tons 1,200 and under 1,400		Tons 1,000 and under 1,200	
22,500 and under 24,200		20,700 and under 22,500		18,800 and under 20,700		16,800 and under 18,800		14,800 and under 16,800	
No.	Size Ins.	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.
6 and cap	4¾	6 and cap	4½	6 and cap	4¼	6 and cap	4⅛	6 and cap	4
	2¼		2⅛		2		1⅞		1⅞
	12×7		11½×6½		11×6		10½×6		10×6
	6		5¾		5½		5¼		5
	1⅞		1¾		1¾		1⅝		1⅝
	1⅝		1½		1½		1⅜		1⅜
3	4¾	3	4⅛	3	4¼	3	4⅛	3	4
2	3½	2	3¼	2	3	2	2¾	2	2⅝
2	4¾	2	4½	2	4¼	2	4⅛	2	4
2	4¾	2	4½	2	4¼	2	4⅛	2	4
	3½		3¼		3		2¾		2⅝
5 and cap	4	5 and cap	3¾	5 and cap	3½	5 and cap	3¼	5	3
3	4	3	3¾	3	3⅜	3	3¼	3	3
2	2¾	2	2½	2	2¼	2	2⅛	2	2
2	4	2	3¾	2	3½	2	3¼	2	3
2	4	2	3¾	2	3½	2	3¼		3
	2¾		2½		2¼		2⅛		2
	3¾		3⅛		3½		3¼		3
	2¾		2⅝		2½		2¼		2⅛
	1 15/16		1 13/16		1 12/16		1 10/16		1 9/16
2	1	2	1	2	⅞	2	⅞	2	15/16

3. Where pole masts are adopted in vessels requiring one cap shroud only, an additional cap shroud is to be fitted, when the number of lower shrouds may be correspondingly reduced.

4. Where double top-gallant yards are to be adopted, a topmast cap backstay should be fitted in addition.

LLOYD'S TABLE OF SIZES FOR THE STEEL

Register Tonnage under Deck	Tons 800 and under 1,000		Tons 700 and under 800		Tons 600 and under 700		Tons 500 and under 600	
Plating Number	12,700 and under 14,800		11,600 and under 12,700		10,300 and under 11,600		9,000 and under 10,300	
	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.	No.	Size Ins.
Fore & Main Shrouds . .	5 and cap	3¾	5 and cap	3½	5 and cap	3¼	5	3
" " Chain plates .		1¾		1¾		1⅝		1⅜
" " Dead-eyes . .		9½ × 5½		9 × 5½		8½ × 5		8 × 5
" " Lanyards (hemp)		4¾		4½		4¼		4
" " Rigging Screws (Diameter at bottom of thread)		1½		1½		1⅜		1¼
" " Rigging Screws (Diameter of Pins)		1⅝		1⅝		1¼		1⅛
" " Topmst. bckstys.	2	3¾	2	3½	2	3¼	2	3
" " Top-gllt. bckstys.	2	2½		2⅜		2¼		2⅛
" " Lower stays .	2	3¾	2	3½	2	3¼	2	3
" " Topmast stays .	2	3¾	2	3½		3¼		3
" " Top-gllt. stays .		2½		2⅜		2¼		2⅛
Mizen Shrouds . . .	5	2⅞	5	2¾	4	2⅝	4	2½
" Topmast backstays .	2	2⅞	2	2¾	2	2⅝		2½
" Top-gallant backstays .		1⅞		1¾		1⅝		1½
" Lower stays . . .		2⅞		2¾		2⅝		2½
" Topmast stays . .		2⅞		2¾		2⅝		2½
" Top-gallant stays . .		1⅞		1¾		1⅝		1½
Bobstay Bar		2½		2¼		2		2
" Pin		1⅞		1⅝		1½		1½
" Chain . . .		1 5/16		1 5/16		1 4/16		1 4/16
Bowsprit Shrouds (Chain) .	2	13/16		13/16		11/16		12/16

5. The steel wire ropes are to be guaranteed to withstand the breaking stress given in the table, and no hemp is to be used in the strands, a hemp core only to be fitted.

6. A short length of each of the wires composing the rigging will be required, after being galvanised, to withstand a tensile stress equivalent to that set forth in the table, and the aggregate strength of the wires must not be less than 10 per cent. in excess of that stress.

WIRE STANDING RIGGING, ETC., OF SAILING SHIPS.

Tons 400 and under 500		Tons 300 and under 400	
7,700 and under 9,000		6,100 and under 7,700	
No.	Size Ins.	No.	Size Ins.
4	$2\frac{3}{4}$	4	$2\frac{1}{2}$
	$1\frac{1}{4}$		$1\frac{1}{4}$
	$7\frac{1}{2}\times4\frac{1}{2}$		$7\times4\frac{1}{2}$
	$3\frac{3}{4}$		$3\frac{1}{2}$
	$1\frac{1}{8}$		$1\frac{1}{8}$
	1		1
2	$2\frac{3}{4}$	2	$2\frac{1}{2}$
	2		$1\frac{3}{4}$
2	$2\frac{3}{4}$	2	$2\frac{1}{2}$
	$2\frac{3}{4}$		$2\frac{1}{2}$
	2		$1\frac{3}{4}$
3	$2\frac{3}{8}$	3	$2\frac{1}{4}$
	$2\frac{3}{8}$		$2\frac{1}{4}$
	$1\frac{5}{8}$		$1\frac{1}{2}$
	$2\frac{3}{8}$		$2\frac{1}{4}$
	$2\frac{3}{8}$		$2\frac{1}{4}$
	$1\frac{5}{8}$		$1\frac{1}{2}$
	2		2
	$1\frac{1}{2}$		$1\frac{1}{2}$
	$1\frac{4}{16}$		$1\frac{3}{16}$
	$\frac{9}{16}$		[illegible]

Steel Wire Standing Rigging			
Size	Breaking Test	Size	Breaking Test
Ins.	Tons	Ins.	Tons
$5\frac{1}{2}$	58	$3\frac{1}{8}$	$17\frac{1}{2}$
$5\frac{1}{4}$	53	3	16
5	48	$2\frac{7}{8}$	$14\frac{1}{2}$
$4\frac{7}{8}$	44	$2\frac{3}{4}$	13
$4\frac{3}{4}$	42	$2\frac{5}{8}$	12
$4\frac{5}{8}$	40	$2\frac{1}{2}$	10
$4\frac{1}{2}$	38	$2\frac{3}{8}$	11
$4\frac{3}{8}$	36	$2\frac{1}{4}$	9
$4\frac{1}{4}$	34	$2\frac{1}{8}$	8
$4\frac{1}{8}$	32	2	7
4	30	$1\frac{7}{8}$	6
$3\frac{7}{8}$	28	$1\frac{3}{4}$	$5\frac{1}{2}$
$3\frac{3}{4}$	26	$1\frac{5}{8}$	5
$3\frac{5}{8}$	24	$1\frac{1}{2}$	4
$3\frac{1}{2}$	22	$1\frac{3}{8}$	$3\frac{1}{4}$
$3\frac{3}{8}$	$20\frac{1}{2}$	$1\frac{1}{4}$	3
$3\frac{1}{4}$	19		

7. Each wire will be required to be capable of being twisted around itself not less than eight times, and of being untwisted and straightened before breaking.

8. Where it is proposed to adopt iron wire rigging, the sizes proposed and the guaranteed tests should be submitted for the consideration of the Committee.

LLOYD'S RULES FOR THE CONSTRUCTION OF IRON AND STEEL MASTS, BOWSPRITS, AND YARDS.

1. If iron be used in the construction of masts, bowsprits, and yards, it is to be of good malleable quality, quite free from surface or other defects, and to stand a tensile strain of 20 tons to the sq. in. and the following bending tests when cold without fracture:—

Thickness of Plates	To Bend Cold through an Angle of	
	With the Grain	Across the Grain
[illegible]	25°	8°
[illegible]	30°	11°
[illegible]	37°	13°
[illegible]	47°	15°
[illegible]	55°	17°
[illegible]	63°	20°
[illegible]	70°	23°

2. The plates to be bent over a slab, the corner of which should be rounded with a radius of half an inch.

3. If steel be adopted, it is to be of the quality required for ship plates, and subjected to the same tests.

4. The butt straps in all cases should be 1-16th of an inch thicker than the plates they connect, in iron masts. In steel masts the butt straps should be 1-20th of an inch thicker than the plates in double-riveted butts, and 1-40th thicker in treble-riveted butts. The butt straps would be better to be fitted on the outside of the masts and bowsprit.

5. The mast and bowsprit plates should be doubled all round in way of the wedging, or otherwise efficiently strengthened; where masts are wedged at the lower deck, the doubling should extend from below the lower deck to above the upper deck.

6. The heels of all masts and their steps should be efficiently strengthened. The cheeks of masts should be stiffened by angles or cope iron on their foremost edges, or by some other approved plan.

7. Where two plates in the round are adopted instead of three, the iron is to be of such superior quality as to admit of its being bent to the required form without being unduly heated and without fracture, and in all such cases the masts should be additionally stiffened by three angles as provided for in the tables.

8. All masts of 64 feet length and above to be fitted with angles properly shifted and extending the whole length of the mast. If the plates be arranged as described in the tables, there should be an angle bar fitted to each plate in the round, of the size given in the table.

9. All bowsprits exceeding 20 inches in diameter should have a vertical diaphragm plate extending from within the wedging to the gammoning, connected by continuous single angle bars to the upper and lower parts of the bowsprit, and two additional angle bars of the size given in the table, and bowsprits 20 inches in diameter and under to have an angle bar at the centre of each plate extending the whole length of the bowsprit.

11. The diameter of the lower masts at the cap to be in no case less than that of the topmast at this place, or of the lower topsail yard.

12. The attention of the Surveyors is to be especially directed to the fittings connected with the masts and rigging, in order to insure the workmanship, material, and sizes of the same being efficient.

13. The mizenmasts for barques may be reduced one-fifth in diameter from that given in the table, and the plating to be not less than the thickness corresponding to the diameters.

14. Where a steamer is intended to be fitted with masts or a bowsprit for auxiliary purposes they may be one-eighth less in diameter than prescribed by table; and when a mast of a steamer is to carry fore and aft sail only the diameter may be one-fifth less than given in the table. The seams of these masts may be single riveted.

15. When pole masts are fitted, the length of the lower masts, in determining the diameter and thickness of plating, should be taken from the heel to the cap band, so as to include the head, as in an ordinary mast; and in sailing vessels these masts should be additionally strengthened, by angles or otherwise, from below the lower yard to the topmast cap, or compensating strength furnished. The cheek plates in pole masts may be of the same thickness as the mast plates at the hounds.

16. The eye-bolts, hoops, cleats and bands are to be of the best description of wrought iron.

17. Any deviations from these rules and tables must be submitted for the consideration of the Committee.

LLOYD'S SIZES FOR BOWSPRITS OF SAILING VESSELS AND FULL-RIGGED STEAM VESSELS.

IRON AND STEEL BOWSPRITS.

Length Outside Bed	Bed			Heel			Cap			Sizes of Angle Bars	
	Diameter	Thickness		Diameter	Thickness		Diameter	Thickness			
		Iron	Steel		Iron	Steel		Iron	Steel	Iron	Steel
Feet	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Inches	Inches
14	$16\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	14	$\frac{5}{16}$	$\frac{6}{20}$	12	$\frac{4}{16}$	$\frac{5}{20}$	$2\frac{1}{2} \times 2 \times \frac{5}{16}$	$2\frac{1}{2} \times 2 \times \frac{6}{20}$
15	$17\frac{1}{2}$	$\frac{5}{16}$	$\frac{6}{20}$	15	$\frac{5}{16}$	[illegible]	$12\frac{1}{2}$	$\frac{5}{16}$	[illegible]	$2\frac{1}{2} \times 2 \times \frac{5}{16}$	$2\frac{1}{2} \times 2 \times \frac{6}{20}$
16	19	$\frac{5}{16}$	$\frac{6}{20}$	16	$\frac{5}{16}$	[illegible]	13	$\frac{5}{16}$	$\frac{6}{20}$	$3 \times 2 \times \frac{5}{16}$	$3 \times 2 \times \frac{6}{20}$
17	20	[illegible]	$\frac{7}{20}$	17	$\frac{6}{16}$	[illegible]	14	$\frac{5}{16}$	$\frac{6}{20}$	$3 \times 2 \times \frac{5}{16}$	$3 \times 2 \times \frac{6}{20}$
18	$21\frac{1}{2}$	[illegible]	$\frac{7}{20}$	18	$\frac{6}{16}$	$\frac{7}{20}$	15	$\frac{5}{16}$	$\frac{6}{20}$	$3 \times 2\frac{1}{2} \times \frac{5}{16}$	$3 \times 2\frac{1}{2} \times \frac{6}{20}$
19	23	$\frac{6}{16}$	$\frac{7}{20}$	19	$\frac{6}{16}$	[illegible]	16	$\frac{5}{16}$	$\frac{6}{20}$	$3 \times 3 \times \frac{6}{16}$	$3 \times 3 \times \frac{7}{20}$
20	$24\frac{1}{2}$	$\frac{7}{16}$	$\frac{8}{20}$	20	[illegible]	[illegible]	$16\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$3\frac{1}{2} \times 3 \times \frac{6}{16}$	$3\frac{1}{2} \times 3 \times \frac{7}{20}$
21	$25\frac{1}{2}$	$\frac{7}{16}$	[illegible]	21	$\frac{6}{16}$	$\frac{7}{20}$	$17\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$3\frac{1}{2} \times 3 \times \frac{6}{16}$	$3\frac{1}{2} \times 3 \times \frac{7}{20}$
22	$26\frac{1}{2}$	$\frac{7}{16}$	[illegible]	22	$\frac{6}{16}$	[illegible]	$18\frac{1}{2}$	[illegible]	$\frac{7}{20}$	$4 \times 3 \times \frac{7}{16}$	$4 \times 3 \times \frac{8}{20}$
23	28	[illegible]	$\frac{8}{20}$	23	$\frac{7}{16}$	$\frac{8}{20}$	19	[illegible]	$\frac{7}{20}$	$4 \times 3\frac{1}{2} \times \frac{7}{16}$	$4 \times 3\frac{1}{2} \times \frac{8}{20}$
24	29	$\frac{8}{16}$	$\frac{9}{20}$	24	$\frac{7}{16}$	$\frac{8}{20}$	20	$\frac{6}{16}$	$\frac{7}{20}$	$4 \times 3\frac{1}{2} \times \frac{7}{16}$	$4 \times 3\frac{1}{2} \times \frac{8}{20}$
25	30	$\frac{8}{16}$	$\frac{9}{20}$	25	$\frac{7}{16}$	$\frac{8}{20}$	21	$\frac{6}{16}$	$\frac{7}{20}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{8}{16}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{9}{20}$
26	$31\frac{1}{2}$	$\frac{8}{16}$	[illegible]	26	$\frac{7}{16}$	$\frac{8}{20}$	$21\frac{1}{2}$	$\frac{6}{16}$	$\frac{7}{20}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{8}{16}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{9}{20}$
27	33	[illegible]	$\frac{9}{20}$	27	$\frac{7}{16}$	$\frac{8}{20}$	22	$\frac{6}{16}$	$\frac{7}{20}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{8}{16}$	$4\frac{1}{2} \times 3\frac{1}{2} \times \frac{9}{20}$

LLOYD'S SIZES AND SCANTLINGS FOR MASTS OF SAIL-

IRON AND

	Extreme Length *	Partners Diameter	Partners Thickness Iron	Partners Thickness Steel	Heel Diameter	Heel Thickness Iron	Heel Thickness Steel	Hounds Diameter	Hounds Thickness Iron	Hounds Thickness Steel	Head Diameter	Head Thickness Iron	Head Thickness Steel
	Feet	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
Two Plates in the Round	48	16	5/16	6/20	13	4/16	5/20	13½	4/16	5/20	11	3/16	3/16
	51	17	5/16	6/20	13½	4/16	5/20	14	4/16	5/20	11½	4/16	5/20
	54	18	5/16	6/20	14	4/16	5/20	15	4/16	5/20	12	4/16	5/20
	57	19	6/16	7/20	15	5/16	6/20	15½	5/16	6/20	12½	4/16	5/20
	60	20	6/16	7/20	16	5/16	6/20	16½	5/16	6/20	13½	5/16	6/20
	63	21	6/16	7/20	16½	5/16	6/20	17½	5/16	6/20	14	5/16	6/20
	66	22	6/16	7/20	17	5/16	6/20	18½	5/16	6/20	14½	5/16	6/20
	69	23	6/16	7/20	18	5/16	6/20	19	5/16	6/20	15½	5/16	6/20
	72	24	6/16	7/20	19	5/16	6/20	20	5/16	6/20	16	5/16	6/20
Three Plates in the Round	75	25	7/16	8/20	19½	6/16	7/20	21	6/16	7/20	16½	6/16	7/20
	78	26	7/16	8/20	20	6/16	7/20	21½	6/16	7/20	17½	6/16	7/20
	81	27	8/16	9/20	21	6/16	7/20	22½	6/16	7/20	18	6/16	7/20
	84	28	8/16	9/20	22	6/16	7/20	23	6/16	7/20	18½	6/16	7/20
	87	29	8/16	9/20	22½	6/16	7/20	24	6/16	7/20	19½	6/16	7/20
	90	30	8/16	9/20	23	7/16	8/20	25	7/16	8/20	20	6/16	7/20
	93	31	9/16	10/20	24	7/16	8/20	26	7/16	8/20	20½	6/16	7/20
	96	32	9/16	10/20	25	7/16	8/20	26½	7/16	8/20	21	6/16	7/20

* The length for regulating the scantlings of the mast to be taken,

ING VESSELS AND FULL-RIGGED STEAM VESSELS.

STEEL MASTS

Sizes of Angle Bars in Masts		Cheeks			
		Thickness of Plate		Sizes of Angle Bar	
Iron	Steel	Iron	Steel	Iron	Steel
Inches	Inches	Ins.	Ins.	Inches	Inches
—	—	$\frac{7}{16}$	$\frac{8}{20}$	$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{6}{16}$	$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{7}{20}$
—	—	$\frac{7}{16}$	$\frac{8}{20}$	$3\frac{1}{2} \times 3 \times \frac{6}{16}$	$3\frac{1}{2} \times 3 \times \frac{7}{20}$
—	—	$\frac{7}{16}$	$\frac{8}{20}$	$3\frac{1}{2} \times 3 \times \frac{6}{16}$	$3\frac{1}{2} \times 3 \times \frac{7}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4 \times 3 \times \frac{7}{16}$	$4 \times 3 \times \frac{8}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4 \times 3 \times \frac{7}{16}$	$4 \times 3 \times \frac{8}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4 \times 3 \times \frac{7}{16}$	$4 \times 3 \times \frac{8}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4\frac{1}{2} \times 3 \times \frac{7}{16}$	$4\frac{1}{2} \times 3 \times \frac{8}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4\frac{1}{2} \times 3 \times \frac{8}{16}$	$4\frac{1}{2} \times 3 \times \frac{9}{20}$
—	—	$\frac{8}{16}$	$\frac{9}{20}$	$4\frac{1}{2} \times 3 \times \frac{8}{16}$	$4\frac{1}{2} \times 3 \times \frac{9}{20}$
—	—	$\frac{9}{16}$	$\frac{10}{20}$	$5 \times 3 \times \frac{8}{16}$	$5 \times 3 \times \frac{9}{20}$
—	—	$\frac{9}{16}$	$\frac{10}{20}$	$5 \times 3 \times \frac{9}{16}$	$5 \times 3 \times \frac{10}{20}$
—	—	$\frac{9}{16}$	$\frac{10}{20}$	$5 \times 3\frac{1}{2} \times \frac{9}{16}$	$5 \times 3\frac{1}{2} \times \frac{10}{20}$
$3\frac{1}{2} \times 3 \times \frac{7}{16}$	$3\frac{1}{2} \times 3 \times \frac{8}{20}$	$\frac{10}{16}$	$\frac{11}{20}$	$5 \times 3\frac{1}{2} \times \frac{9}{16}$	$5 \times 3\frac{1}{2} \times \frac{10}{20}$
$4 \times 3 \times \frac{7}{16}$	$4 \times 3 \times \frac{8}{20}$	$\frac{10}{16}$	$\frac{11}{20}$	$5\frac{1}{2} \times 4 \times \frac{10}{16}$	$5\frac{1}{2} \times 4 \times \frac{11}{20}$
$4 \times 3 \times \frac{8}{16}$	$4 \times 3 \times \frac{9}{20}$	$\frac{10}{16}$	$\frac{11}{20}$	$6 \times 4 \times \frac{10}{16}$	$6 \times 4 \times \frac{11}{20}$
$4\frac{1}{2} \times 3 \times \frac{8}{16}$	$4\frac{1}{2} \times 3 \times \frac{9}{20}$	$\frac{11}{16}$	$\frac{12}{20}$	$6 \times 4 \times \frac{10}{16}$	$6 \times 4 \times \frac{11}{20}$
$5 \times 3 \times \frac{8}{16}$	$5 \times 3 \times \frac{9}{20}$	$\frac{11}{16}$	$\frac{12}{20}$	$6 \times 4 \times \frac{10}{16}$	$6 \times 4 \times \frac{11}{20}$

in all cases, from the cap to the top of the keelson.

TABLE GIVING DISTANCES OF FOREIGN PORTS FROM LONDON IN NAUTICAL MILES.

Aberdeen	423
Aden	4,605 / 9,355
Alexandria	3,095
Amsterdam	233
Antwerp	182
Archangel	2,320
Auckland	10,916 / 12,120
Barbadoes	3,794
Barcelona	1,903
Batavia (Java)	8,330 / 11,970
Bombay	6,280 / 10,595
Bordeaux	650
Boston	3,025
Bristol	634
Buenos Ayres	6,280
Cadiz	1,322
Calcutta	7,980 / 11,480
Canton	10,463 / 12,563
Cape of Good Hope	6,065
Cape Horn	7,396
Cardiff	517
Charlestown	4,207
Colombo (Ceylon)	6,795 / 10,885
Constantinople	3,065
Copenhagen	708
Cork	531
Dover	87
Dublin	580
Dundee	420
Ferrol	765
Funchal (Madeira)	1,397
Gibraltar	1,320
Glasgow	725
Halifax	2,692
Hamburg	419
Havanna	4,239
Hobart Town	10,291 / 11,495
Hong Kong	9,775 / 13,910
Hull	203
Kingston (Jamaica)	3,968
Leghorn	2,258
Leith	418
Lima	10,655
Lisbon	1,063
Liverpool	660
Lizard	347
Madras	[illegible] / [illegible]
Malacca	[illegible] / [illegible]
Malta	[illegible]
Manilla	[illegible]
Mauritius	[illegible]
Melbourne	[illegible] / [illegible]
New Orleans	[illegible]
New York	[illegible]
New Zealand	[illegible] / 11,835
Ostend	118
Otago	12,190
Pekin (Gulf)	11,925 / 15,060
Pernambuco	4,180
Plymouth	315
Port Jackson	11,817 / 13,021
Portsmouth	195
Pulo Penang	8,868 / 11,963
Quebec	2,930
Rangoon	8,095 / 11,580
Rio Janeiro	5,200
Rotterdam	195
San Francisco	13,670
Shanghai	10,845 / 13,690
Sheerness	43
Shields	315
Sierra Leone	2,997
Singapore	8,345 / 11,670
Southampton	210
St. Helena	4,526
St. Iago (Cape Verde Is.)	2,672
St. John (Newfoundland)	2,090
St. Petersburg	1,457
Stockholm	1,108
Swan River	10,428 / 11,620
Sydney	10,840 / 12,044
Teneriffe	1,720
Venice	3,126
Washington	3,880
Waterford	608
Yokohama	11,343 / 14,576

TONNAGE.

Register or New Measurement Tonnage.

The gross register tonnage of a ship expresses her entire cubical capacity in tons of 100 cubic feet each, and may be found approximately by the following formula:—

L = the inside length on upper deck from plank at stem to plank at stern.

B = the inside main breadth from ceiling to ceiling.

D = the inside midship depth from upper deck to ceiling at limber strake.

$$\text{Register tonnage} = \frac{L \times B \times D}{100} C.$$

Value of C.

Sailing ships	cotton and sugar ships, old full form	·8
	ships of the present usual form .	·7
Steam vessels and clippers	ships of two decks	·65
	ships of three decks . . .	·68
Yachts	above sixty tons	·5
	under sixty tons	·45

To Calculate the Gross Register Tonnage.

The tonnage deck is the upper deck in all vessels under three decks, in all other vessels the second deck from below.

Measurements to be expressed in feet and the decimals of a foot.

The length for register tonnage is taken from inside of plank at stem to inside of midship stern timber, or plank there, as the case may be, and is taken on the tonnage deck; the length so taken (having made deductions for the rake of stem and stern, if any, in the thickness of the deck, and one-third of the round of the beam) is to be divided into the prescribed number of equal parts, according to the length, as follows:—

Length.	No. of Intervals.
Not exceeding 50 feet and under	4
Exceeding 50 feet and not exceeding 120 feet. .	6
Exceeding 120 feet and not exceeding 180 feet. .	8
Exceeding 180 feet and not exceeding 225 feet. .	10
Exceeding 225 feet	12

Transverse sections are then measured at each of the points of division, as follows:—

The total depths of the transverse sections are measured from the under side of the tonnage deck to the ceiling at the inner edge of limber strake, deducting one-third of the round of the beam. The depths so taken are to be divided into four equal parts, if midship depth should not exceed sixteen feet; otherwise into six equal parts.

The breadths are measured horizontally at the points of division, and also at the upper and lower points of each depth, each measurement extending to the average thickness of that part of the ceiling which is between the points of measurement.

The areas of the transverse sections are then computed by Simpson's first rule (p. 39), and then the capacity of the ship is computed by the same rule (Rule 2, p. 47)—that is, the areas are treated as the ordinates of a new curve of the same length as the vessel; and the area of that new curve, found by Simpson's first rule, will be the capacity of the vessel in cubic feet, which being divided by 100 gives the gross register tonnage under tonnage deck.

The capacity of the poop, deck houses, and other permanently enclosed spaces available for cargo or passengers is to be measured and included in the register tonnage, but the following deductions are allowed, the remainder then being deemed the *register tonnage* of the ship.

Deductions Allowed from the Gross Tonnage.—(1) Buildings for the shelter of passengers only. (2) Space allotted to crew (for crew space see p. 383). (3) *Propelling space.* Screw steamers: if the cubic content is 13 and under 20 per cent. of the gross tonnage, deduct 32 per cent.; if the space is smaller than 13 and larger than 20 per cent., deduct either 32 per cent. or the cubic content multiplied by 1·75. Paddle steamers: if the cubic content is 20 and under 30 per cent. of the gross tonnage, deduct 37 per cent., and if the space is smaller than 20 or larger than 30 per cent., deduct either 37 per cent. or the cubic content multiplied by 1·5.

Factors for Measurement and Dead-weight Cargoes.

1. *To ascertain approximately for an average length of voyage the measurement cargo, at 40 feet to the ton, which a ship can carry.*

Rule.—Multiply the number of register tons by the factor 1·875, and the product will be the approximate measurement cargo.

2. *To ascertain approximately the dead-weight cargo in tons which a ship can carry on an average length of voyage.*

Rule.—Multiply the number of register tons by 1·5, and the product will be the approximate dead-weight cargo required.

With regard to the cargoes of coasters and colliers as ascertained above, about 10 per cent. may be added to the said results, while about 10 per cent. may be deducted in the cases of larger vessels going longer voyages.

In the case of measurement cargoes of steam vessels the spaces

occupied by the machinery, fuel, and passenger cabins under the deck must be deducted from the space or tonnage under the deck before the application of the measurement factor thereto.

In the case of dead-weight cargoes, the weight of machinery, water in the boilers, and fuel must be deducted from the whole dead weight, as ascertained above by the application of the dead-weight factor.

The deductions necessary to be made for provisions, stores. &c., are allowed for in the selection of the two factors.

Builder's Tonnage, or Old Measurement Tonnage.

To Compute the Builder's Tonnage.

Rule.—Measure the length of the vessel along the rabbet of the keel from the back of the main stern-post to a perpendicular line let fall from the fore part of the main stem under the bowsprit; measure also the extreme breadth to the outside planking, exclusive of doubling planks. Three-fifths of that breadth is to be subtracted from the length; the remainder is called the length of keel for tonnage. Multiply the length of keel for tonnage by the breadth, that product by the half-breadth, and divide by 94; the quotient will be the tonnage.

If L = length, B = breadth, then

$$\text{Tonnage (B.O.M.)} = \frac{(L - \frac{3}{5}B) \times B \times \frac{1}{2}B}{94}.$$

Measurement of Yachts for Tonnage.

Royal Thames Yacht Club.

Rule.—Measure the length of the yacht in a straight line at the deck from the fore part of the stem to the after part of the stern-post, from which deduct the extreme breadth, which is measured from the outside of the outside planking; the remainder is the length for tonnage. Multiply the length for tonnage by the extreme breadth, that product by half the extreme breadth, and divide the result by 94; the quotient will be the tonnage. If any part of the stem or stern-post project beyond the length as taken above, such projection or projections shall, for the purpose of finding the tonnage, be added to the length taken as before mentioned. All fractional parts of a ton shall be considered as a ton. The measurement to be taken either above or below the main-wale. If L = length, B = breadth, then

$$\text{Tonnage} = \frac{(L - B) \times B \times \frac{1}{2}B}{94}.$$

TABLE OF THE TONNAGES OF VESSELS ACCORDING TO BUILDER'S MEASUREMENT.

In the following tables tonnages are only given for vessels whose lengths are multiples of 10, except at the head of each group, where the tonnage for each extra foot of length up to 9 feet is given, in order that the tonnages of vessels whose lengths are not given in these tables may be found by a simple addition, as per example.

Ex.—Required the tonnage of a vessel 207 feet long and 22·5 feet beam.

Tonnage for 200 feet length $= 502\frac{19}{94}\cdot813$
Tonnage for extra 7 feet length $= 18\frac{79}{94}\cdot875$
Tonnage for 207 feet length $= 521\frac{5}{94}\cdot688$

Note.—In the tables the ninety-fourths of a ton are divided from the tons by a dash; thus, $126\frac{18}{94}\cdot125 = 126–18\cdot125$.

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			10 FEET BEAM				
1	0–50	5	2–62	9	4–74	60	28–68
2	1–6	6	3–18	30	12–72	70	34–4
3	1–56	7	3–68	40	18–8	80	39–34
4	2–12	8	4–24	50	23–38	90	44–64
			10·5 FEET BEAM				
1	0–55·125	5	2–87·625	9	5–26·125	60	31–46·213
2	1–16·25	6	3–48·75	30	13–84·463	70	37–33·463
3	1–71·375	7	4–9·875	40	19–71·713	80	43–20·713
4	2–32·5	8	4–65·0	50	25–58·963	90	49–7·963
			11 FEET BEAM				
1	0–60·5	6	3–81·0	40	21–46·7	90	53–63·7
2	1–27·0	7	4–47·5	50	27–87·7	100	60–10·7
3	1–87·5	8	5–14·0	60	34–34·7	110	66–51·7
4	2–54·0	9	5–74·5	70	40–75·7	120	72–92·7
5	3–20·5	30	15–5·7	80	47–22·7	130	79–39·7
			11·5 FEET BEAM				
1	0–66·125	6	4–20·75	40	23–26·738	90	58–42·988
2	1–38·25	7	4–86·875	50	30–29·988	100	65–46·238
3	2–10·375	8	5–59·0	60	37–33·238	110	72–49·488
4	2–76·5	9	6–31·125	70	44–36·488	120	79–52·738
5	3–48·625	30	16–23·488	80	51–39·738	130	86–55·988
			12 FEET BEAM				
1	0–72	6	4–56	50	32–73	100	71–7
2	1–50	7	5–34	60	40–41	110	78–69
3	2–28	8	6–12	70	48–9	120	86–37
4	3–6	9	6–84	80	55–71	130	94–5
5	3–78	40	25–11	90	63–39	140	101–67

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
12·5 FEET BEAM							
1	0–78·125	6	4–92·75	50	35–30·313	100	76–82·563
2	1–62·25	7	5–76·875	60	43–59·563	110	85–17·813
3	2–46·375	8	6–61·0	70	51–88·813	120	93–47·063
4	3–30·5	9	7–45·125	80	60–24·063	130	101–76·313
5	4–14·625	40	27–1·063	90	68–53·313	140	110–11·563
13 FEET BEAM							
1	0–84·5	6	5–37·0	50	37–87·9	100	82–82·9
2	1–75·0	7	6–27·5	60	46–86·9	110	91–81·9
3	2–65·5	8	7–18·0	70	55–85·9	120	100–80·9
4	3–56·0	9	8–8·5	80	64–84·9	130	109–79·9
5	4–46·5	40	28–88·9	90	73–83·9	140	118–78·9
13·5 FEET BEAM							
1	0–91·125	6	5–76·75	50	40–58·138	100	89–8·388
2	1–88·25	7	6–73·875	60	50–29·388	110	98–73·638
3	2–85·375	8	7–71·0	70	60–0·638	120	108–44·888
4	3–82·5	9	8–68·125	80	89–65·888	130	118–16·138
5	4–79·625	40	30–86·888	90	79–37·138	140	127–81·388
14 FEET BEAM							
1	1–4	6	6–24	50	43–34	100	95–46
2	2–8	7	7–28	60	53–74	110	105–86
3	3–12	8	8–32	70	64–20	120	116–32
4	4–16	9	9–36	80	74–60	130	126–72
5	5–20	40	32–88	90	85–6	140	137–18
14·5 FEET BEAM							
1	1–11·125	6	6–66·75	60	57–34·913	110	113–27·163
2	2–22·25	7	7–77·875	70	38–52·163	120	124–44·413
3	3–33·375	8	8–89·0	80	79–69·413	130	135–61·663
4	4–44·5	9	10–6·125	90	90–86·663	140	146–78·913
5	5–55·625	50	46–17·663	100	102–9·913	150	158–2·163
15 FEET BEAM							
1	1–18·5	6	7–17·0	60	61–3·5	110	120–82·5
2	2–37·0	7	8–35·5	70	73–0·5	120	132–79·5
3	3–55·5	8	9–54·0	80	84–91·5	130	144–76·5
4	4–74·0	9	10–72·5	90	96–88·5	140	156–73·5
5	5–92·5	50	49–6·5	100	108–85·5	150	168–70·5
15·5 FEET BEAM							
1	1–26	7	8–88	80	90–32·838	140	167–2·338
2	2–52	8	10–21	90	103–12·088	150	179–75·588
3	3–78	9	11–47	100	115–85·338	160	192–54·838
4	5–10	50	52–1·088	110	128–64·588	170	205–34·088
5	6–36	60	64–74·338	120	141–43·838	180	218–13·338
6	7–62	70	77–53·588	130	154–23·088	190	230–86·588

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
16 FEET BEAM							
1	1–34	7	9–50	80	95–81	140	177–53
2	2–68	8	10–84	90	109–45	150	191–17
3	4–8	9	12–24	100	123–9	160	204–75
4	5–42	50	55–1	110	136–67	170	218–39
5	6–76	60	68–59	120	150–31	180	232–3
6	8–16	70	82–23	130	163–89	190	245–61
16·5 FEET BEAM							
1	1–42·125	7	10–12·875	80	101–48·363	140	188–37·863
2	2–84·25	8	11–55·0	90	115–93·613	150	202–83·113
3	4–32·375	9	13–3·125	100	130–44·863	160	217–34·363
4	5–74·5	50	58–6·613	110	144–90·113	170	231–79·613
5	7–28·625	60	72–51·863	120	159–41·363	180	246–30·863
6	8–64·75	70	87–3·113	130	173–86·613	190	260–76·113
17 FEET BEAM							
1	1–50·5	7	10–71·5	80	107–28·1	140	199–50·1
2	3–7·0	8	12–28·0	90	122–63·1	150	214–85·1
3	4–57·5	9	13–78·5	100	138–4·1	160	230–26·1
4	6–14·0	50	61–17·1	110	153–39·1	170	245–61·1
5	7–64·5	60	76–52·1	120	168–74·1	180	261–2·1
6	9–21·0	70	91–87·1	130	184–15·1	190	276–37·1
17·5 FEET BEAM							
1	1–59·125	7	11–37·875	80	113–20·188	140	210–89·688
2	3–24·25	8	13–3·0	90	129–47·438	150	227–22·938
3	4–83·375	9	14–62·125	100	145–74·688	160	243–50·188
4	6–48·5	50	64–32·438	110	162–7·938	170	259–77·438
5	8–13·625	60	80–59·688	120	178–35·188	180	276–10·688
6	9–72·75	70	96–86·938	130	194–62·438	190	292–37·938
18 FEET BEAM							
1	1–68	7	12–6	80	119–24	140	222–62
2	3–42	8	13–74	90	136–46	150	239–84
3	5–16	9	15–48	100	153–68	160	257–12
4	6–84	50	67–52	110	170–90	170	274–34
5	8–58	60	84–74	120	188–18	180	291–56
6	10–32	70	102–2	130	205–40	190	308–78
18·5 FEET BEAM							
1	1–77·125	8	14–53·0	100	161–79·013	170	289–25·763
2	3–60·25	9	16–36·125	110	180–4·263	180	307–45·013
3	5–43·375	50	70–76·763	120	198–23·513	190	325–64·263
4	7–26·5	60	89–2·013	130	216–42·763	200	343–83·513
5	9–9·625	70	107–21·263	140	234–62·013	210	362–8·763
6	10–86·75	80	125–40·513	150	252–81·263	220	380–28·013
7	12–69·873	90	143–59·763	160	271–6·513	230	398–47·263

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			19 FEET BEAM				
1	1–86·5	8	15–34·0	100	170–12·3	170	304–51·3
2	3–79·0	9	17–26·5	110	189–31·3	180	323–70·3
3	5–71·5	50	74–11·3	120	208–50·3	190	342–89·3
4	7–64·0	60	93–30·3	130	227–69·3	200	362–14·3
5	9–56·5	70	112–49·3	140	246–88·3	210	381–33·3
6	11–49·0	80	131–68·3	150	266–13·3	220	400–52·3
7	13–41·5	90	150–87·3	160	285–32·3	230	419–71·3
			19·5 FEET BEAM				
1	2–2·125	9	18–19·125	120	219–4·538	200	380–80·538
2	4–4·25	50	77–43·788	130	239–25·788	210	401–7·788
3	6–6·375	60	97–65·038	140	259–47·038	220	421–29·038
4	8–8·5	70	117–86·288	150	279–68·288	230	441–50·288
5	10–10·625	80	138–13·538	160	299–89·538	240	461–71·538
6	12–12·75	90	158–34·788	170	320–16·788	250	481–92·788
7	14–14·875	100	178–56·038	180	340–38·038	260	502–20·038
8	16–17·0	110	198–77·288	190	360–59·288	270	522–41·288
			20 FEET BEAM				
1	2–12	9	19–14	130	251–6	210	421–26
2	4–24	60	102–12	140	272–32	220	442–52
3	6–36	70	123–38	150	293–58	230	463–78
4	8–48	80	144–64	160	314–84	240	485–10
5	10–60	90	165–90	170	336–16	250	506–36
6	12–72	100	187–22	180	357–42	260	527–62
7	14–84	110	208–48	190	378–68	270	548–88
8	17–2	120	229–74	200	400–0	280	570–20
			20·5 FEET BEAM				
1	2–22·125	9	20–11·125	130	263–9·713	210	441–87·713
2	4–44·25	60	106–58·963	140	285–42·963	220	464–26·963
3	6–66·375	70	128–92·213	150	307–76·213	230	486–60·213
4	8–88·5	80	151–31·463	160	330–15·463	240	508–93·463
5	11–16·625	90	173–64·713	170	352–48·713	250	531–32·713
6	13–38·75	100	196–3·963	180	374–81·963	260	553–65·963
7	15–60·875	110	218–37·213	190	397–21·213	270	576–5·213
8	17–83·0	120	240–70·463	200	419–54·463	280	598–38·463
			21 FEET BEAM				
1	2–32·5	9	21–10·5	130	275–36·7	210	463–4·7
2	4–65·0	60	111–17·7	140	298–79·7	220	486–47·7
3	7–3·5	70	134–60·7	150	322–28·7	230	509–90·7
4	9–36·0	80	158–9·7	160	345–71·7	240	533–39·7
5	11–68·5	90	181–52·7	170	369–20·7	250	556–82·7
6	14–7·0	100	205–1·7	180	392–63·7	260	580–31·7
7	16–39·5	110	228–44·7	190	416–12·7	270	603–74·7
8	18–72·0	120	251–87·7	200	439–55·7	280	627–23·7

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
21·5 FEET BEAM							
1	2–43·125	9	22–12·125	130	287–86·738	210	484–58·738
2	4–86·25	60	115–75·988	140	312–47·988	220	509–19·988
3	7–35·375	70	140–37·238	150	337–9·238	230	533–75·238
4	9–78·5	80	164–92·488	160	361–64·488	240	558–36·488
5	12–27·625	90	189–53·738	170	386–25·738	250	582–91·738
6	14–70·75	100	214–14·988	180	410–80·988	260	607–52·988
7	17–19·875	110	238–70·238	190	435–42·238	270	632–14·238
8	19–63·0	120	263–31·488	200	460–3·488	280	656–69·488
22 FEET BEAM							
1	2–54	9	23–16	130	300–65	210	506–61
2	5–14	60	120–45	140	326–41	220	532–37
3	7–68	70	146–21	150	352–17	230	558–13
4	10–28	80	171–91	160	377–87	240	583–83
5	12–82	90	197–67	170	403–63	250	609–59
6	15–42	100	223–43	180	429–39	260	635–35
7	18–2	110	249–19	190	455–15	270	661–11
8	20–56	120	274–89	200	480–85	280	686–81
22·5 FEET BEAM							
1	2–65·125	9	24–22·125	130	313–67·063	210	529–13·063
2	5–36·25	60	125–20·313	140	340–60·313	220	556–6·313
3	8–7·375	70	152–13·563	150	367–53·563	230	582–93·563
4	10–72·5	80	179–6·813	160	394–46·813	240	609–86·813
5	13–43·625	90	206–0·063	170	421–40·063	250	636–80·063
6	16–14·75	100	232–87·313	180	448–33·313	260	663–73·313
7	18–79·875	110	259–80·563	190	475–26·563	270	690–66·563
8	21–51·0	120	286–73·813	200	502–19·813	280	717–59·813
23 FEET BEAM							
1	2–76·5	9	25–30·5	130	326–90·9	210	552–6·9
2	5–59·0	60	129–93·9	140	355–9·9	220	580–19·9
3	8–41·5	70	158–12·9	150	383–22·9	230	608–32·9
4	11–24·0	80	186–25·9	160	411–35·9	240	636–45·9
5	14–6·5	90	214–38·9	170	439–48·9	250	664–58·9
6	16–83·0	100	242–51·9	180	467–61·9	260	692–71·9
7	19–65·5	110	270–64·9	190	495–74·9	270	720–84·9
8	22–48·0	120	298–77·9	200	523–87·9	280	749–3·9
23·5 FEET BEAM							
1	2–88·125	9	26–41·125	140	369–78·138	220	604–78·138
2	5–82·25	70	164–19·388	150	399–19·388	230	634–19·388
3	8–76·375	80	193–54·638	160	428–54·638	240	663–54·638
4	11–70·5	90	222–89·888	170	457–89·888	250	692–89·888
5	14–64·625	100	252–31·138	180	487–31·138	260	722–31·138
6	17–58·75	110	281–66·388	190	516–66·388	270	751–66·388
7	20–52·875	120	311–7·638	200	546–7·638	280	781–7·638
8	23–47·0	130	340–42·888	210	575–42·888	290	810–42·888

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			24 FEET BEAM				
1	3–6	9	27–54	140	384–76	220	629–86
2	6–12	70	170–32	150	415–42	230	660–52
3	9–18	80	200–92	160	446–8	240	691–18
4	12–24	90	231–58	170	476–68	250	721–78
5	15–30	100	262–24	180	507–34	260	752–44
6	18–36	110	292–84	190	538–0	270	783–10
7	21–42	120	323–50	200	568–60	280	813–70
8	24–48	130	354–16	210	599–26	290	844–36
			24·5 FEET BEAM				
1	3–18·125	9	28–69·125	140	400–5·663	220	655–45·663
2	6–36·25	70	176–52·913	150	431–92·913	230	687–38·913
3	9–54·375	80	208–46·163	160	463–86·163	240	719–32·163
4	12–72·5	90	240–39·413	170	495–79·413	250	751–25·413
5	15–90·625	100	272–32·663	180	527–72·663	260	783–18·663
6	19–14·75	110	304–25·913	190	559–65·913	270	815–11·913
7	22–32·875	120	336–19·163	200	591–59·163	280	847–5·163
8	25–51·0	130	368–12·413	210	623–52·413	290	878–92·413
			25 FEET BEAM				
1	3–30·5	9	29–86·5	140	415–52·5	220	681–48·5
2	6–61·0	70	182–79·5	150	448–75·5	230	714–71·5
3	9–91·5	80	216–8·5	160	482–4·5	240	748–0·5
4	13–28·0	90	249–31·5	170	515–27·5	250	781–23·5
5	16–58·5	100	282–54·5	180	548–50·5	260	814–46·5
6	19–89·0	110	315–77·5	190	581–73·5	270	847–69·5
7	23–25·5	120	349–6·5	200	615–2·5	280	880–92·5
8	26–56·0	130	382–29·5	210	648–25·5	290	914–21·5
			25·5 FEET BEAM				
1	3–43·125	9	31–12·125	140	431–29·088	220	708–1·088
2	6–86·25	70	189–18·338	150	465–84·338	230	742–56·338
3	10–35·375	80	223–73·588	160	500–45·588	240	777–17·588
4	13–78·5	90	258–34·838	170	535–6·838	250	811–72·838
5	17–27·625	100	292–90·088	180	569–62·088	260	846–34·088
6	20–70·75	110	327–51·338	190	604–23·338	270	880–89·338
7	24–19·875	120	362–12·588	200	638–78·588	280	915–50·588
8	27–63·0	130	396–67·838	210	673–39·838	290	950–11·838
			26 FEET BEAM				
1	3–56	9	32–34	140	447–29	220	734–91
2	7–18	70	195–57	150	483–25	230	770–87
3	10–74	80	231–53	160	519–21	240	806–83
4	14–36	90	267–49	170	555–17	250	842–79
5	17–92	100	303–45	180	591–13	260	878–75
6	21–54	110	339–41	190	627–9	270	914–71
7	25–16	120	375–37	200	663–5	280	950–67
8	28–72	130	411–33	210	699–1	290	986–63

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			26·5 FEET BEAM				
1	3–69·125	9	33–58·125	140	463–52·613	220	762–36·613
2	7–44·25	70	202–7·863	150	500–85·863	230	799–69·863
3	11–19·375	80	239–41·113	160	538–25·113	240	837–9·113
4	14–88·5	90	276–74·363	170	575–58·363	250	874–42·363
5	18–63·625	100	314–13·613	180	612–91·613	260	911–75·613
6	22–38·75	110	351–46·863	190	650–30·863	270	949–14·863
7	26–13·875	120	388–80·113	200	687–64·113	280	986–48·113
8	29–83·0	130	426–19·363	210	725–3·363	290	1023–81·363
			27 FEET BEAM				
1	3–82·5	9	34–84·5	140	480–5·1	220	790–25·1
2	7–71·0	70	208–58·1	150	518–78·1	230	829–4·1
3	11–59·5	80	247–37·1	160	557–57·1	240	867–77·1
4	15–48·0	90	286–16·1	170	596–36·1	250	906–56·1
5	19–36·5	100	324–89·1	180	635–15·1	260	945–35·1
6	23–25·0	110	363–68·1	190	673–88·1	270	984–14·1
7	27–13·5	120	402–47·1	200	712–67·1	280	1022–87·1
8	31–32·0	130	441–26·1	210	751–46·1	290	1061–66·1
			27·5 FEET BEAM				
1	4–2·125	9	36–19·125	150	537–1·688	230	858–77·688
2	8–4·25	80	255–40·938	160	577–22·938	240	899–4·938
3	12–6·375	90	295–62·188	170	617–44·188	250	939–26·188
4	16–8·5	100	335–83·438	180	657–65·438	260	979–47·438
5	20–10·625	110	376–10·688	190	697–86·688	270	1019–68·688
6	24–12·75	120	416–31·938	200	738–13·938	280	1059–89·938
7	28–14·875	130	456–53·188	210	778–35·188	290	1100–17·188
8	32–17·0	140	496–74·438	220	818–56·438	300	1140–38·438
			28 FEET BEAM				
1	4–16	9	37–50	150	555–44	230	889–8
2	8–32	80	263–52	160	597–16	240	930–74
3	12–48	90	305–24	170	638–82	250	972–46
4	16–64	100	346–90	180	680–54	260	1014–18
5	20–80	110	388–62	190	722–26	270	1055–84
6	25–2	120	430–34	200	763–92	280	1097–56
7	29–18	130	472–6	210	805–64	290	1139–28
8	33–34	140	513–72	220	847–36	300	1181–0
			28·5 FEET BEAM				
1	4–30·125	9	38–83·125	150	574–18·013	230	919–78·013
2	8–60·25	80	271–71·263	160	617–37·263	240	963–3·263
3	12–90·375	90	314–90·513	170	660–56·513	250	1006–22·513
4	17–26·5	100	358–15·763	180	703–75·763	260	1049–41·763
5	21–56·625	110	401–35·013	190	747–1·013	270	1092–61·013
6	25–86·75	120	444–54·263	200	790–20·263	280	1135–80·263
7	30–22·875	130	487–73·513	210	833–89·513	290	1179–5·513
8	34–53·0	140	530–92·763	220	876–58·763	300	1222–24·763

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			29 FEET BEAM				
1	4–44·5	9	40–24·5	150	593–16·3	230	951–4·3
2	8–89·0	80	280–3·3	160	637–85·3	240	995–73·3
3	13–39·5	90	324–72·3	170	682–60·3	250	1040–48·3
4	17–84·0	100	369–47·3	180	727–35·3	260	1085–23·3
5	22–34·5	110	414–22·3	190	772–10·3	270	1129–92·3
6	26–79·0	120	458–91·3	200	816–79·3	280	1174–67·3
7	31–29·5	130	503–66·3	210	861–54·3	290	1219–42·3
8	35–74·0	140	548–41·3	220	906–29·3	300	1264–17·3
			29·5 FEET BEAM				
1	4–59·125	9	41–62·125	150	612–39·038	230	982–69·038
2	9–24·25	80	288–36·288	160	658–66·288	240	1029–2·288
3	13–83·375	90	334–63·538	170	704–93·538	250	1075–29·538
4	18–48·5	100	380–90·788	180	751–26·788	260	1121–56·788
5	23–13·625	110	427–24·038	190	797–54·038	270	1167–84·038
6	27–72·75	120	473–51·288	200	843–81·288	280	1214–17·288
7	32–37·875	130	519–78·538	210	890–14·538	290	1260–44·538
8	37–3·0	140	566–11·788	220	936–41·788	300	1306–71·788
			30 FEET BEAM				
1	4–74	9	43–8	160	679–74	240	1062–72
2	9–54	90	344–64	170	727–62	250	1110–60
3	14–34	100	392–52	180	775–50	260	1158–48
4	19–14	110	440–40	190	823–38	270	1206–36
5	23–88	120	488–28	200	871–26	280	1254–24
6	28–68	130	536–16	210	919–14	290	1302–12
7	33–48	140	584–4	220	967–2	300	1350–0
8	38–28	150	631–86	230	1014–84	310	1397–82
			30·5 FEET BEAM				
1	4–89·125	9	44–50·125	160	701–14·213	240	1097–0·213
2	9–84·25	90	354–73·463	170	750–59·463	250	1146–45·463
3	14–79·375	100	404–24·713	180	800–10·713	260	1195–90·713
4	19–74·5	110	453–69·963	190	849–55·963	270	1245–41·963
5	24–69·625	120	503–21·213	200	899–7·213	280	1294–87·213
6	29–64·75	130	552–66·463	210	948–52·463	290	1344–38·463
7	34–59·875	140	602–17·713	220	998–3·713	300	1393–83·713
8	39–55·0	150	651–62·963	230	1047–48·963	310	1443–34·963
			31 FEET BEAM				
1	5–10·5	9	46–0·5	160	722–74·7	240	1131–68·7
2	10–21·0	90	364–91·7	170	773–85·7	250	1182–79·7
3	15–31·5	100	416–8·7	180	825–2·7	260	1233–90·7
4	20–42·0	110	467–19·7	190	876–13·7	270	1285–7·7
5	25–52·5	120	518–30·7	200	927–24·7	280	1336–18·7
6	30–63·0	130	569–41·7	210	978–35·7	290	1387–29·7
7	35–73·5	140	620–52·7	220	1026–49·7	300	1438–40·7
8	40–84·0	150	671–63·7	230	1080–57·7	310	1489–51·7

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
31·5 FEET BEAM							
1	5–26·125	9	47–47·125	170	797–46·488	250	1219–68·488
2	10–52·25	100	428–3·738	180	850–25·738	260	1272–47·738
3	15–78·375	110	480–76·988	190	903–4·988	270	1325–26·988
4	21–10·5	120	533–56·238	200	955–78·238	280	1378–6·238
5	26–36·625	130	586–35·488	210	1008–57·488	290	1430–79·488
6	31–62·75	140	639–14·738	220	1061–36·738	300	1483–58·738
7	36–88·875	150	691–87·988	230	1114–15·988	310	1536–37·988
8	42–21·0	160	744–67·238	240	1166–89·238	320	1589–17·238
32 FEET BEAM							
1	5–42	100	440–9	190	930–29	280	1240–49
2	10–84	110	494–53	200	984–73	290	1474–93
3	16–32	120	549–3	210	1039–23	300	1529–43
4	21–74	130	603–47	220	1093–67	310	1583–87
5	27–22	140	657–91	230	1148–17	320	1638–37
6	32–64	150	712–41	240	1202–61	330	1692–81
7	38–12	160	766–85	250	1257–11	340	1747–31
8	43–54	170	821–35	260	1311–55	350	1801–75
9	49–2	180	875–79	270	1366–5	360	1856–25
32·5 FEET BEAM							
1	5–58·125	100	452–26·063	190	957–87·313	280	1463–54·563
2	11–22·25	110	508–43·313	200	1014–10·563	290	1519–71·813
3	16–80·375	120	564–60·563	210	1070–27·813	300	1575–89·063
4	22–44·5	130	620–77·813	220	1126–45·063	310	1632–12·313
5	28–8·625	140	677–1·063	230	1182–62·313	320	1688–29·563
6	33–66·75	150	733–18·313	240	1238–79·563	330	1744–46·813
7	39–30·875	160	789–35·563	250	1295–2·813	340	1800–64·063
8	44–89·0	170	845–52·813	260	1351–20·063	350	1856–81·313
9	50–53·125	180	901–70·063	270	1407–37·313	360	1913–4·563
33 FEET BEAM							
1	5–74·5	100	464–52·9	190	985–83·9	280	1507–20·9
2	11–55·0	110	522–45·9	200	1043–76·9	290	1565–13·9
3	17–35·5	120	580–38·9	210	1101–69·9	300	1623–6·9
4	23–16·0	130	638–31·9	220	1159–62·9	310	1680–93·9
5	28–90·5	140	696–24·9	230	1217–55·9	320	1738–86·9
6	34–71·0	150	754–17·9	240	1275–48·9	330	1796–79·9
7	40–51·5	160	812–10·9	250	1333–41·9	340	1854–72·9
8	46–32·0	170	870–3·9	260	1391–34·9	350	1912–65·9
9	52–12·5	180	927–90·9	270	1449–27·9	360	1970–58·9
33·5 FEET BEAM							
1	5–91·125	6	35–76·75	110	536–61·138	160	835–11·388
2	11–88·25	7	41–73·875	120	596–32·388	170	894–76·638
3	17–85·375	8	47–71·0	130	656–3·638	180	954–47·888
4	23–82·5	9	53–68·125	140	715–68·888	190	1014–19·138
5	29–79·625	100	476–89·888	150	775–40·138	200	1073–84·388

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
33·5 FEET BEAM (concluded)							
210	1133–55·638	250	1372–34·638	290	1611–13·638	330	1849–86·638
220	1193–26·888	260	1432–5·888	300	1670–78·888	340	1909–57·888
230	1252–92·138	270	1491–71·138	310	1730–50·138	350	1969–29·138
240	1312–63·388	280	1551–42·388	320	1790–21·388	360	2029–0·388
34 FEET BEAM							
1	6–14	100	489–42	190	1042–80	280	1596–24
2	12–28	110	550–88	200	1104–32	290	1657–70
3	18–42	120	612–40	210	1165–78	300	1719–22
4	24–56	130	673–86	220	1227–30	310	1780–68
5	30–70	140	735–38	230	1288–76	320	1842–20
6	36–84	150	796–84	240	1350–28	330	1903–66
7	43–4	160	858–36	250	1411–74	340	1965–18
8	49–18	170	919–82	260	1473–26	350	2026–64
9	55–32	180	981–34	270	1534–72	360	2088–16
34·5 FEET BEAM							
1	6–31·125	100	502–5·413	190	1071–80·663	280	1641–61·913
2	12–62·25	110	565–34·663	200	1135–15·913	290	1704–91·163
3	18–93·375	120	628–63·913	210	1198–45·163	300	1768–26·413
4	25–30·5	130	691–93·163	220	1261–74·413	310	1831–55·663
5	31–61·625	140	755–28·413	230	1325–9·663	320	1894–84·913
6	37–92·75	150	818–57·663	240	1388–38·913	330	1958–20·163
7	44–29·875	160	881–86·913	250	1451–68·163	340	2021–49·413
8	50–61·0	170	945–22·163	260	1515–3·413	350	2084–78·663
9	56–92·125	180	1008–51·413	270	1578–32·663	360	2148–13·913
35 FEET BEAM							
1	6–48·5	100	514–71·5	190	1101–18·5	280	1687–59·5
2	13–3·0	110	579–86·5	200	1166–33·5	290	1752–74·5
3	19–51·5	120	645–7·5	210	1231–48·5	300	1817–89·5
4	26–6·0	130	710–22·5	220	1296–63·5	310	1883–10·5
5	32–54·5	140	775–37·5	230	1361–78·5	320	1948–25·5
6	39–9·0	150	840–52·5	240	1426–93·5	330	2013–40·5
7	45–57·5	160	905–67·5	250	1492–14·5	340	2078–55·5
8	52–12·0	170	970–82·5	260	1557–29·5	350	2143–70·5
9	58–60·5	180	1036–3·5	270	1622–44·5	360	2208–85·5
35·5 FEET BEAM							
1	6–66·125	100	527–52·838	190	1130–82·088	280	1734–17·338
2	13–38·25	110	594–56·088	200	1197–85·338	290	1801–20·588
3	20–10·375	120	661–59·338	210	1264–88·588	300	1868–23·838
4	26–76·5	130	728–62·588	220	1331–91·838	310	1935–27·088
5	33–48·625	140	795–65·838	230	1399–1·088	320	2002–30·338
6	40–20·75	150	862–69·088	240	1466–4·338	330	2069–33·588
7	46–86·875	160	929–72·338	250	1533–7·588	340	2136–36·838
8	53–59·0	170	996–75·588	260	1600–10·838	350	2203–40·088
9	60–31·125	180	1063–78·838	270	1667–14·088	360	2270–43·338

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			36 FEET BEAM				
1	6–84	110	609–37	210	1298–71	310	1988–11
2	13–74	120	678–31	220	1367–65	320	2057–5
3	20–64	130	747–25	230	1436–59	330	2125–93
4	27–54	140	816–19	240	1505–53	340	2194–87
5	34–44	150	885–13	250	1574–47	350	2263–81
6	41–34	160	954–7	260	1643–41	360	2332–75
7	48–24	170	1023–1	270	1712–35	370	2401–69
8	55–14	180	1091–89	280	1781–29	380	2470–63
9	62–4	190	1160–83	290	1850–23	390	2539–57
100	540–43	200	1229–77	300	1919–17	400	2608–51
			36·5 FEET BEAM				
1	7–8·125	110	624–29·613	210	1332–90·113	310	2041–56·613
2	14–16·25	120	695–16·863	220	1403–77·363	320	2112–43·863
3	21–24·375	130	766–4·113	230	1474–64·613	330	2183–31·113
4	28–32·5	140	836–85·363	240	1545–51·863	340	2254–18·363
5	35–40·625	150	907–72·613	250	1616–39·113	350	2325–5·613
6	42–48·75	160	978–59·863	260	1687–26·363	360	2395–86·863
7	49–56·875	170	1049–47·113	270	1758–13·613	370	2466–74·113
8	56–65·0	180	1120–34·363	280	1829–0·863	380	2537–61·363
9	63–73·125	190	1191–21·613	290	1899–82·113	390	2608–48·613
100	553–42·363	200	1262–8·863	300	1970–69·363	400	2679–35·863
			37 FEET BEAM				
1	7–26·5	120	712–16·1	220	1440–34·1	320	2168–52·1
2	14–53·0	130	784–93·1	230	1513–17·1	330	2241–35·1
3	21–79·5	140	857–76·1	240	1586–0·1	340	2314–18·1
4	29–12·0	150	930–59·1	250	1658–77·1	350	2387–1·1
5	36–38·5	160	1003–42·1	260	1731–60·1	360	2459–78·1
6	43–65·0	170	1076–25·1	270	1804–43·1	370	2532–61·1
7	50–91·5	180	1149–8·1	280	1877–26·1	380	2605–44·1
8	58–24·0	190	1221–85·1	290	1950–9·1	390	2678–27·1
9	65–50·5	200	1294–68·1	300	2022–86·1	400	2751–10·1
110	639–33·1	210	1367–51·1	310	2095–69·1	410	2823–87·1
			37·5 FEET BEAM				
1	7–45·125	120	729–28·688	220	1477–29·188	320	2225–29·688
2	14–90·25	130	804–9·938	230	1552–10·438	330	2300–10·938
3	22–41·375	140	878–85·188	240	1626–85·688	340	2374–86·188
4	29–86·5	150	953–66·438	250	1701–66·938	350	2449–67·438
5	37–37·625	160	1028–47·688	260	1776–48·188	360	2524–48·688
6	44–82·75	170	1103–28·938	270	1851–29·438	370	2599–29·938
7	52–33·875	180	1178–10·188	280	1926–10·688	380	2674–11·188
8	59–79·0	190	1252–85·438	290	2000–85·938	390	2748–86·438
9	67–30·125	200	1327–66·688	300	2075–67·188	400	2823–67·688
110	654–47·438	210	1402–47·938	310	2150–48·438	410	2898–48·938

Lgth. in Ft.	TONS	Lgth in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			38 FEET BEAM				
1	7–64	120	746–54	220	1514–62	320	2282–70
2	15–34	130	823–36	230	1591–44	330	2359–52
3	23–4	140	900–18	240	1668–26	340	2436–34
4	30–68	150	977–0	250	1745–8	350	2513–16
5	38–38	160	1053–76	260	1821–84	360	2589–92
6	46–8	170	1130–58	270	1898–66	370	2666–74
7	53–72	180	1207–40	280	1975–48	380	2743–56
8	61–42	190	1284–22	290	2052–30	390	2820–38
9	69–12	200	1361–4	300	2129–12	400	2897–20
110	669–62	210	1437–80	310	2205–88	410	2974–2
			38·5 FEET BEAM				
1	7–83·125	120	763–93·013	220	1552–39·513	320	2340–80 01
2	15–72·25	130	842–78·263	230	1631–24·763	330	2419–65·26
3	23–61·375	140	921–63·513	240	1710–10·013	340	2498–50·51
4	31–50·5	150	1000–48·763	250	1788–89·263	350	2577–35·76
5	39–39·625	160	1079–34·013	260	1867–74·513	360	2656–21·01
6	47–28·75	170	1158–19·263	270	1946–59·763	370	2735–6·263
7	55–17·875	180	1237–4·513	280	2025–45·013	380	2813–85·51
8	63–7·0	190	1315–83·763	290	2104–30·263	390	2892–70·76
9	70–90·125	200	1394–69·013	300	2183–15·513	400	2971–56·01
110	685–13·763	210	1473–54·263	310	2262–0·763	410	3050–41·26
			39 FEET BEAM				
1	8–8·5	120	781–50·3	220	1590–54·3	320	2399–58·3
2	16–17·0	130	862–41·3	230	1671–45·3	330	2480–49·3
3	24–25·5	140	943–32·3	240	1752–36·3	340	2561–40·3
4	32–34·0	150	1024–23·3	250	1833–27·3	350	2642–31·3
5	40–42·5	160	1105–14·3	260	1914–18·3	360	2723–22·3
6	48–51·0	170	1186–5·3	270	1995–9·3	370	2804–13·3
7	56–59·5	180	1266–90·3	280	2076–0·3	380	2885–4·3
8	64–68·0	190	1347–81·3	290	2156–85·3	390	2965–89·3
9	72–76·5	200	1428–72·3	300	2237–76·3	400	3046–80·3
110	700–59·3	210	1509–63·3	310	2318–67·3	410	3127–71·3
			39·5 FEET BEAM				
1	8–28·125	120	799–20·038	220	1629–12·538	320	2459–5·038
2	16–56·25	130	882–19·288	230	1712–11·788	330	2542–4·288
3	24–84·375	140	965–18·538	240	1795–11·038	340	2625–3·538
4	33–18·5	150	1048–17·788	250	1878–10·288	350	2708–2·788
5	41–46·625	160	1131–17·038	260	1961–9·538	360	2791–2·038
6	49–74·75	170	1214–16·288	270	2044–8·788	370	2874–1·288
7	58–8·875	180	1297–15·538	280	2127–8·038	380	2957–0·538
8	66–37·0	190	1380–14·788	290	2210–7·288	390	3039–93·78
9	74–65·125	200	1463–14·038	300	2293–6·538	400	3122–93·03
110	716–20·788	210	1546–13·288	310	2376–5·788	410	3205–92·28

h. t.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
			40 FEET BEAM				
1	8–48	130	902–12	230	1753–18	330	2604–24
2	17–2	140	987–22	240	1838–28	340	2689–34
3	25–50	150	1072–32	250	1923–38	350	2774–44
4	34–4	160	1157–42	260	2008–48	360	2859–54
5	42–52	170	1242–52	270	2093–58	370	2944–64
6	51–6	180	1327–62	280	2178–68	380	3029–74
7	59–54	190	1412–72	290	2263–78	390	3114–84
8	68–8	200	1497–82	300	2348–88	400	3200–0
9	76–56	210	1582–92	310	2434–4	410	3285–10
0	817–2	220	1668–8	320	2519–14	420	3370–20
			40·5 FEET BEAM				
1	8–68·125	130	922–19·213	230	1794–63·713	330	2667–14·213
2	17–42·25	140	1009–42·463	240	1881–86·963	340	2754–37·463
3	26–16·375	150	1096–65·713	250	1969–16·213	350	2841–60·713
4	34–84·5	160	1183–88·963	260	2056–39·463	360	2928–83·963
5	43–58·625	170	1271–18·213	270	2143–62·713	370	3016–13·213
6	52–32·75	180	1358–41·463	280	2230–85·963	380	3103–36·463
7	61–6·875	190	1445–64·137	290	2318–15·213	390	3190–59·713
8	69–75·0	200	1532–87·963	300	2405–38·463	400	3277–82·963
9	78–49·125	210	1620–17·213	310	2492–61·713	410	3365–12·213
20	834–89·963	220	1707–40·463	320	2579–84·963	420	3452–35·463
			41 FEET BEAM				
1	8–88·5	130	942–40·7	230	1836–54·7	330	2730–68·7
2	17–83·0	140	1031–79·7	240	1925–93·7	340	2820–13·7
3	26–77·5	150	1121–24·7	250	2015–38·7	350	2909–52·7
4	35–72·0	160	1210–63·7	260	2104–77·7	360	2998–91·7
5	44–66·5	170	1300–8·7	270	2194–22·7	370	3088–36·7
6	53–61·0	180	1389–47·7	280	2283–61·7	380	3177–75·7
7	62–55·5	190	1478–86·7	290	2373–6·7	390	3267–20·7
8	71–50·0	200	1568–31·7	300	2462–45·7	400	3356–59·7
9	80–44·5	210	1657–70·7	310	2551–84·7	410	3446–4·7
20	853–1·7	220	1747–15·7	320	2641–29·7	420	3535–43·7
			41·5 FEET BEAM				
1	9–15·125	130	962–76·238	230	1878–84·738	330	2794–93·238
2	18–30·25	140	1054–39·488	240	1970–47·988	340	2886–56·488
3	27–45·375	150	1146–2·738	250	2062–11·238	350	2978–19·738
4	36–60·5	160	1237–59·988	260	2153–68·488	360	3069–76·988
5	45–75·625	170	1329–23·238	270	2245–31·738	370	3161–40·238
6	54–90·75	180	1420–80·488	280	2336–88·988	380	3253–3·488
7	64–11·875	190	1512–43·738	290	2428–52·238	390	3344–60·738
8	73–27·0	200	1604–6·988	300	2520–15·488	400	3436–23·988
9	82–42·125	210	1695–64·238	310	2611–72·738	410	3527–81·238
20	871–18·988	220	1787–27·488	320	2703–35·988	420	3619–44·488

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
42 FEET BEAM							
1	9–36	140	1077–15	250	2109–27	360	3141–39
2	18–72	150	1170–93	260	2203–11	370	3235–23
3	28–14	160	1264–77	270	2296–89	380	3329–7
4	37–50	170	1358–61	280	2390–73	390	3422–85
5	46–86	180	1452–45	290	2484–57	400	3516–69
6	56–28	190	1546–29	300	2578–41	410	3610–53
7	65–64	200	1640–13	310	2672–25	420	3704–37
8	75–6	210	1733–91	320	2766–9	430	3798–21
9	84–42	220	1827–75	330	2859–87	440	3892–5
120	889–47	230	1921–59	340	2953–71	450	3985–83
130	983–31	240	2015–43	350	3047–55	460	4079–67
42·5 FEET BEAM							
1	9–57·125	140	1100–7·813	250	2156–87·563	360	3213–73·313
2	19–20·25	150	1196–15·063	260	2253–0·813	370	3309–80·563
3	28–77·375	160	1292–22·313	270	2349–8·063	380	3405–87·813
4	38–40·5	170	1388–29·563	280	2445–15·313	390	3502–1·063
5	48–3·625	180	1484–36·813	290	2541–22·563	400	3598–8·313
6	57–60·75	190	1580–44·063	300	2637–29·813	410	3694–15·563
7	67–23·875	200	1676–51·313	310	2733–37·063	420	3790–22·813
8	76–81·0	210	1772–58·563	320	2829–44·313	430	3886–30·063
9	86–44·125	220	1868–65·813	330	2925–51·563	440	3982–37·313
120	907–87·313	230	1964–73·063	340	3021–58·813	450	4078–44·563
130	1004–0·563	240	2060–80·313	350	3117–66·063	460	4174–51·813
43 FEET BEAM							
1	9–78·5	140	1123–15·9	250	2205–2·9	360	3286–83·9
2	19–63·0	150	1221–48·9	260	2303–35·9	370	3385–22·9
3	29–47·5	160	1319–81·9	270	2401–68·9	380	3483–55·9
4	39–32·0	170	1418–20·9	280	2500–7·9	390	3581–88·9
5	49–16·5	180	1516–53·9	290	2598–40·9	400	3680–27·9
6	59–1·0	190	1614–86·9	300	2696–73·9	410	3778–60·9
7	68–79·5	200	1713–25·9	310	2795–12·9	420	3876–93·9
8	78–64·0	210	1811–58·9	320	2893–45·9	430	3975–32·9
9	88–48·5	220	1909–91·9	330	2991–78·9	440	4073–65·9
120	926–43·9	230	2008–30·9	340	3090–17·9	450	4172–4·9
130	1024–76·9	240	2106–63·9	350	3188–50·9	460	4270–37·9
43·5 FEET BEAM							
1	10–6·125	9	90–55·125	200	1750–31·138	280	2555–51·138
2	20–12·25	130	1045–72·388	210	1850–92·388	290	2656–18·388
3	30–18·375	140	1146–39·638	220	1951–59·638	300	2756–79·638
4	40–24·5	150	1247–6·888	230	2052–26·888	310	2857–46·888
5	50–30·625	160	1347–68·138	240	2152–88·138	320	2958–14·138
6	60–36·75	170	1448–35·388	250	2253–55·388	330	3058–75·388
7	70–42·875	180	1549–2·638	260	2354–22·638	340	3159–42·638
8	80–49·0	190	1649–63·888	270	2454–83·888	350	3260–9·888

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
43·5 FEET BEAM (concluded)							
360	3360–71·188	390	3662–66·888	420	3964–62·638	450	4266–58·388
370	3461–38·388	400	3763–34·138	430	4065–29·888	460	4367–25·638
380	3562–5·638	410	3864–1·388	440	4165–91·138	470	4467–86·888
44 FEET BEAM							
1	10–28	150	1272–76	260	2405–54	370	3538–32
2	20–56	160	1375–74	270	2508–52	380	3641–30
3	30–84	170	1478–72	280	2611–50	390	3744–28
4	41–18	180	1581–70	290	2714–48	400	3847–26
5	51–46	190	1684–68	300	2817–46	410	3950–24
6	61–74	200	1787–66	310	2920–44	420	4053–22
7	72–8	210	1890–64	320	3023–42	430	4156–20
8	82–36	220	1993–62	330	3126–40	440	4259–18
9	92–64	230	2096–60	340	3229–38	450	4362–16
130	1066–80	240	2199–58	350	3332–36	460	4465–14
140	1169–78	250	2302–56	360	3435–34	470	4568–12
44·5 FEET BEAM							
1	10–50·125	150	1298–70·413	260	2457–38·163	370	3616–5·913
2	21–6·25	160	1404–7·663	270	2562–69·413	380	3721–37·163
3	31–56·375	170	1509–38·913	280	2668–6·663	390	3826–68·413
4	42–12·5	180	1614–70·163	290	2773–37·913	400	3932–5·663
5	52–62·625	190	1720–7·413	300	2878–69·163	410	4037–36·913
6	63–18·75	200	1825–38·663	310	2984–6·413	420	4142–68·163
7	73–68·875	210	1930–69·913	320	3089–37·663	430	4248–5·413
8	84–25·0	220	2036–7·163	330	3194–68·913	440	4353–36·663
9	94–75·125	230	2141–38·413	340	3300–6·163	450	4458–67·913
130	1088–7·913	240	2246–69·663	350	3405–37·413	460	4564–5·163
140	1193–39·163	250	2352–6·913	360	3510–68·663	470	4669–36·413
45 FEET BEAM							
1	10–72·5	150	1324–81·5	260	2509–66·5	370	3694–51·5
2	21–51·0	160	1432–54·5	270	2617–39·5	380	3802–24·5
3	32–29·5	170	1540–27·5	280	2725–12·5	390	3909–91·5
4	43–8·0	180	1648–0·5	290	2832–79·5	400	4017–64·5
5	53–80·5	190	1755–67·5	300	2940–52·5	410	4125–37·5
6	64–59·0	200	1863–40·5	310	3048–25·5	420	4233–10·5
7	75–37·5	210	1971–13·5	320	3155–92·5	430	4340–77·5
8	86–16·0	220	2078–80·5	330	3263–65·5	440	4448–50·5
9	96–88·5	230	2186–53·5	340	3371–38·5	450	4556–23·5
130	1109–41·5	240	2294–26·5	350	3479–11·5	460	4663–90·5
140	1217–14·5	250	2401–93·5	360	3586–78·5	470	4771–63·5
45·5 FEET BEAM							
1	11–1·125	4	44–4·5	7	77–7·875	130	1130–87·338
2	22–2·25	5	55–5·625	8	88–9·0	140	1241–4·588
3	33–3·375	6	66–6·75	9	99–10·125	150	1351–15·838

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
45·5 FEET BEAM (concluded)							
160	1461–27·088	240	2342–23·088	320	3223–19·088	400	4104–15·088
170	1571–38·338	250	2452–34·338	330	3333–30·338	410	4214–26·338
180	1681–49·588	260	2562–45·588	340	3443–41·588	420	4324–37·588
190	1791–60·838	270	2672–56·838	350	3553–52·838	430	4434–48·838
200	1901–72·088	280	2782–68·088	360	3663–64·088	440	4544–60·088
210	2011–83·338	290	2892–79·338	370	3773–75·338	450	4654–71·338
220	2122–0·588	300	3002–90·588	380	3883–86·588	460	4764–82·588
230	2232–11·838	310	3113–7·838	390	3994–3·838	470	4874–93·838
46 FEET BEAM							
1	11–24	150	1377–61	260	2615–69	370	3853–77
2	22–48	160	1490–19	270	2728–27	380	3966–35
3	33–72	170	1602–71	280	2840–79	390	4078–87
4	45–2	180	1715–29	290	2953–37	400	4191–45
5	56–26	190	1827–81	300	3065–89	410	4304–3
6	67–50	200	1940–39	310	3178–47	420	4416–55
7	78–74	210	2052–91	320	3291–5	430	4529–13
8	90–4	220	2165–49	330	3403–57	440	4641–65
9	101–28	230	2278–7	340	3516–15	450	4754–23
130	1152–51	240	2390–59	350	3628–67	460	4866–75
140	1265–9	250	2503–17	360	3741–25	470	4979–83
46·5 FEET BEAM							
1	11–47·125	150	1404–29·363	260	2669–43·113	370	3934–56·863
2	23–0·25	160	1519–30·613	270	2784–44·363	380	4049–58·113
3	34–47·375	170	1634–31·863	280	2899–45·613	390	4164–59·363
4	46–0·5	180	1749–33·113	290	3014–46·863	400	4279–60·613
5	57–47·625	190	1864–34·363	300	3129–48·113	410	4394–61·863
6	69–0·75	200	1979–35·613	310	3244–49·363	420	4509–63·113
7	80–47·875	210	2094–36·863	320	3359–50·613	430	4624–64·363
8	92–1·0	220	2209–38·113	330	3474–51·863	440	4739–65·613
9	103–48·125	230	2324–39·363	340	3589–53·113	450	4854–66·863
130	1174–26·863	240	2439–40·613	350	3704–54·363	460	4969–68·113
140	1289–28·113	250	2554–41·863	360	3819–55·613	470	5084–69·363
47 FEET BEAM							
1	11–70·5	160	1548–61·1	270	2841–14·1	380	4133–61·1
2	23–47·0	170	1666–14·1	280	2958–61·1	390	4251–14·1
3	35–23·5	180	1783–61·1	290	3076–14·1	400	4368–61·1
4	47–0·0	190	1901–14·1	300	3193–61·1	410	4486–14·1
5	58–70·5	200	2018–61·1	310	3311–14·1	420	4603–61·1
6	70–47·0	210	2136–14·1	320	3428–61·1	430	4721–14·1
7	82–23·5	220	2253–61·1	330	3546–14·1	440	4838–61·1
8	94–0·0	230	2371–14·1	340	3663–61·1	450	4956–14·1
9	105–70·5	240	2488–61·1	350	3781–14·1	460	5073–61·1
140	1313–61·1	250	2606–14·1	360	3898–61·1	470	5191–14·1
150	1431–14·1	260	2723–61·1	370	4016–14·1	480	5308–61·1

47·5 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	12–0·125	160	1578–16·438	270	2898–30·188	380	4218–43·938
2	24–0·25	170	1698–17·688	280	3018–31·438	390	4338–45·188
3	36–0·375	180	1818–18·938	290	3138–32·688	400	4458–46·438
4	48–0·5	190	1938–20·188	300	3258–33·938	410	4578–47·688
5	60–0·625	200	2058–21·438	310	3378–35·188	420	4698–48·938
6	72–0·75	210	2178–22·688	320	3498–36·438	430	4818–50·188
7	84–0·875	220	2298–23·938	330	3618–37·688	440	4938–51·438
8	96–1·0	230	2418–25·188	340	3738–38·938	450	5058–52·688
9	108–1·125	240	2538–26·438	350	3858–40·188	460	5178–53·938
140	1338–13·938	250	2658–27·688	360	3978–41·438	470	5298–55·188
150	1458–15·188	260	2778–28·938	370	4098–42·688	480	5418–56·438

48 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	12–24	160	1607–84	270	2955–92	380	4304–6
2	24–48	170	1730–42	280	3078–50	390	4426–58
3	36–72	180	1853–0	290	3201–8	400	4549–16
4	49–2	190	1975–52	300	3323–60	410	4671–68
5	61–26	200	2098–10	310	3446–18	420	4794–26
6	73–50	210	2220–62	320	3568–70	430	4916–78
7	85–74	220	2343–20	330	3691–28	440	5039–36
8	98–4	230	2465–72	340	3813–80	450	5161–88
9	110–28	240	2588–30	350	3936–38	460	5284–46
140	1362–74	250	2710–82	360	4058–90	470	5407–4
150	1485–32	260	2833–40	370	4181–48	480	5529–56

48·5 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	12–48·125	170	1762–88·013	290	3264–85·013	410	4765–76·013
2	25–2·25	180	1888–5·263	300	3389–46·263	420	4890–87·263
3	37–50·375	190	2013–16·513	310	3514–57·513	430	5016–4·513
4	50–4·5	200	2138–27·763	320	3639–68·763	440	5141–15·763
5	62–52·625	210	2263–39·013	330	3764–80·013	450	5266–27·013
6	75–6·75	220	2388–50·263	340	3889–91·263	460	5391–38·263
7	87–54·875	230	2513–61·513	350	4015–8·513	470	5516–49·513
8	100–9·0	240	2638–72·763	360	4140–19·763	480	5641–60·763
9	112–57·125	250	2763–84·013	370	4265–31·013	490	5766–72·013
140	1387–54·263	260	2889–1·263	380	4390–42·263	500	5891–83·263
150	1512–65·513	270	3014–12·513	390	4515–53·513	510	6017–0·513
160	1637–76·763	280	3139–23·763	400	4640–64·763	520	6142–11·763

49 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	12–72·5	8	102–16·0	190	2051–6·3	260	2945–5·3
2	25–51·0	9	114–88·5	200	2178–73·3	270	3072–72·3
3	38–29·5	140	1412–47·3	210	2306–46·3	280	3200–45·3
4	51–8·0	150	1540–20·3	220	2434–19·3	290	3328–18·3
5	63–80·5	160	1667–87·3	230	2561–86·3	300	3455–85·3
6	76–59·0	170	1795–60·3	240	2689–59·3	310	3583–58·3
7	89–37·5	180	1923–33·3	250	2817–32·3	320	3711–31·3

49 FEET BEAM (concluded)

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
330	3839–4·3	380	4477–57·3	430	5116–16·3	480	5754–69·3
340	3966–71·3	390	4605–30·3	440	5243–83·3	490	5882–42·3
350	4094–44·3	400	4733–3·3	450	5371–56·3	500	6010–5·3
360	4222–17·3	410	4860–70·3	460	5499–29·3	510	6137–72·3
370	4349–84·3	420	4988–43·3	470	5627–2·3	520	6265–45·3

49·5 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	13–3·125	170	1828–53·038	290	3392–52·038	410	4956–51·038
2	26–6·25	180	1958–84·288	300	3522–83·288	420	5086–82·288
3	39–9·375	190	2089–21·538	310	3653–20·538	430	5217–19·538
4	52–12·5	200	2219–52·788	320	3783–51·788	440	5347–50·788
5	65–15·625	210	2349–84·038	330	3913–83·038	450	5477–82·038
6	78–18·75	220	2480–21·288	340	4041–20·288	460	5608–19·288
7	91–21·875	230	2610–52·538	350	4174–51·538	470	5738–50·538
8	104–25·0	240	2740–83·788	360	4304–82·788	480	5868–81·788
9	117–28·125	250	2871–21·038	370	4435–20·038	490	5999–19·038
140	1437–53·288	260	3001–52·288	380	4565–51·288	500	6129–50·288
150	1567–84·538	270	3131–83·538	390	4695–82·538	510	6259–81·538
160	1698–21·788	280	3262–20·788	400	4826–19·788	520	6390–18·788

50 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	13–28	180	1994–64	300	3590–40	420	5186–16
2	26–56	190	2127–62	310	3723–38	430	5319–14
3	39–84	200	2260–60	320	3856–36	440	5452–12
4	53–18	210	2393–58	330	3989–34	450	5585–10
5	66–46	220	2526–56	340	4122–32	460	5718–8
6	79–74	230	2659–54	350	4255–30	470	5861–6
7	93–8	240	2792–52	360	4388–28	480	5984–4
8	106–36	250	2925–50	370	4521–26	490	6117–2
9	119–64	260	3058–48	380	4654–24	500	6250–0
150	1595–70	270	3191–46	390	4787–22	510	6382–92
160	1728–68	280	3324–44	400	4920–20	520	6515–90
170	1861–66	290	3457–42	410	5053–18	530	6648–88

50·5 FEET BEAM

Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS	Lgth. in Ft.	TONS
1	13–53·125	180	2030–66·213	300	3658–49·213	420	5286–32·213
2	27–12·25	190	2166–33·463	310	3794–16·463	430	5421–93·463
3	40–65·375	200	2302–0·713	320	3929–77·713	440	5557–60·713
4	54–24·5	210	2437–61·963	330	4065–44·963	450	5693–27·963
5	67–77·625	220	2573–29·213	340	4201–12·213	460	5828–89·213
6	81–36·75	230	2708–90·463	350	4336–73·463	470	5964–56·463
7	94–89·875	240	2844–57·713	360	4472–40·713	480	6100–23·713
8	108–49·0	250	2980–24·963	370	4608–7·963	490	6235–84·963
9	122–8·125	260	3115–86·213	380	4743–69·213	500	6371–52·213
150	1623–70·463	270	3251–53·463	390	4879–36·463	510	6507–19·463
160	1759–37·713	280	3387–20·713	400	5015–3·713	520	6642–80·713
170	1895–4·963	290	3522–81·963	410	5150–64·963	530	6778–47·963

VOCABULARY OF TECHNICAL TERMS USED IN SHIPBUILDING.

ENGLISH—FRENCH.

Abaft, en arrière
Aboard, à bord
Admiral, amiral
Admiralty, amirauté
Adze, herminette
Afloat, à flot
Aft, arrière, de l'arrière
Air pump, pompe à air
A-lee, sous le vent
Amidships, au milieu du navire
Anchor, ancre
Angle iron, cornière, fer d'angle
Apron, radier, contre-étrave, platine
Ash, frêne
Astern, à l'arrière, de l'arrière
Athwart, par le travers
Awning, tente
Azimuth compass, compas de variation
Back of stern-post, contre-étambot
Backstay, galhauban
Barge, grand canot, allège
Bar iron, fer en barres
Barque, barque, bateau
Barrel of the capstan, mèche du cabestan
Barrel of the steering wheel, tambour de la roue du gouvernail
Batten, liteau
Beam, bau
Beech, hêtre
Bending press, machine à cintrer les tôles
Between-decks, entrepont
Bevel, angle oblique, angle d'équerrage
Bilge, petit fond d'un navire
Bilge pump, pompe de cale
Bilge ways, coittes
Binnacle, habitacle
Bitts, bittes
Blade of a screw, aile d'hélice
Blister steel, acier poule
Block, poulie, moufle
Block and fall, palan
Boarding pike, pique d'abordage
Boat, bateau, canot
Boatswain, maître d'équipage
Bobstay, sous-barbe
Body plan, plan vertical
Boiler maker, chaudronnier
Boiler plate, tôle
Bollard, corps mort
Bolt, cheville, boulon
Bolt rope, ralingue
Boom, bout dehors, arc-boutant
Bow, l'avant d'un vaisseau
Bower-anchor, ancre du bossoir
Bowsprit, beaupré
Brace, bras
Bracket, courbaton
Brail, cargue
Bread room, soute au pain
Breadth extreme, plus grande largeur
Breaker, brisant, baril de galère
Breast-plate, conscience
Brig, brig
Brigantine, brigantin
Bucket, baille
Builder, constructeur
Bulk head, cloison
Bunker, soute
Bunt-line, cargue-fond
Buoy, bouée, balise
Buoyant, léger, émergé
Burton, petit palan
Butt, about, tête d'un couple
Butt cover, plaque de jonction d'écart de tôle
Cabin, cabine, chambre, lit
Cable, câble
Cable tier, fosse aux câbles

ENGLISH INTO FRENCH (continued).

Caisson, bateau-porte
Cant, oblique, tringle
Cant timbers, couples dévoyés
Capstan, cabestan
Careen, carène
Cargo, cargaison, chargement
Carling, entremise, aillure
Cast iron, fonte de fer
Cast-iron girder, poutre en fonte
Cast iron pipe, tuyau en fonte
Cast steel, acier fondu
Cat-head, bossoir
Cat's-paw, fraîcheur, petite brise
Caulk (to), calfater
Caulker, calfat
Chain, chaîne, câble-chaîne
Cheeks of a mast, jottereaux
Clack valve, clapet
Clamp, bauquière, jumelle
Cleat, taquet
Clew, point d'écoute
Clew garnets, cargues-points
Coal bunker, soute alimentaire
Coamings, chambranles
Coaster, caboteur
Cockpit, théâtre
Cockswain, patron de chaloupe
Coffer-dam, bâtardeau
Commander, capitaine de frégate
Companion, capot d'échelle
Compass, boussole, compas de route
Copper, cuivre
Copper-bottomed, doublé en cuivre
Cordage, cordages
Corvette, corvette
Counter, grande voûte
Countersink, fraisure
Countersunk head, tête fraisée
Course, route, basse-voile
Crab, cabestan volant
Crab winch, virevaut, treuil
Cradle, berceau
Craft, petit navire
Crane, grue
Crank shaft, arbre à manivelle
Cringle, aguiée, ancette
Cross-tree, barre de hune
Crow-bar, presson, pince
Cruiser, croiseur
Crutches, fourcats
Cutter, cutter, cotre
Cutwater, taille-mer, éperon
Davit, davier
Dead-eyes, caps de mouton
Dead-light, faux mantelet
Dead-wood, courbes de remplissage
Deal, bordage mince
Deck, pont, tillac
Deck planks, bordages des ponts
Deck stopper, bosse à bouton
Delivery pipe, tuyau d'écoulement
Delivery valve, clapet de décharge
Depth of hold, creux de cale
Distilling apparatus, appareil distillatoire
Dock, bassin, darse
Dockyard, arsenal
Down-haul, hale-bas
Draught of water, tirant d'eau
Dredging machine, cure-môle à vapeur, machine à draguer
Drill, foret, mèche
Drilling machine, machine à percer
Driver, tapecul, paille-en-cul
Driving wheel, roue motrice
Drum, tambour
Dry dock, forme sèche, forme de radoub
Dunnage, fardage
Ebb, reflux, jusant
Elevation, élévation, projection verticale
Elm, orme
Endless chain, chaîne sans fin
Engine, machine
Engine-bearer, carlingue

ENGLISH INTO FRENCH (continued).

Engine room, chambre de la machine
Ensign, pavillon de poupe
Eye bolt, cheville à œillet
False keel, fausse quille
Fathom, brasse
Feathering paddle, aube articulée
Feathering paddle-wheel, roue à aubes articulées
Feed pump, pompe alimentaire
Fender, défense
Ferry, gué
Ferry boat, bateau de passage
Fid, clef
Figured dimension, quote
File, lime
Filling piece, pièce de remplissage
Fir wood, sapin
Fire ship, brûlot
Fish pendant, pantoire de la candelette de l'ancre
Fish-tackle fall, garant de la candelette
Flange, collerette, collet
Flange joint, joint à collet
Flare, revers
Floating body, corps flottant
Floor, fond d'un navire
Floor heads, têtes des varangues
Floor timbers, varangues
Flukes, oreilles d'une ancre
Flush deck, pont entier
Flush joint, assemblage bout à bout
Flush rivet, rivet à tête fraisée
Fly wheel, volant
Flying jib, petit foc, clinfoc
Flying jibboom, bout dehors de clinfoc
Force pump, pompe foulante
Forecastle, gaillard d'avant
Fore mast, mât de misaine
Fore sheets, écoutes
Fore stay, étai de misaine
Fore staysail halliard, drisse de la trinquette du petit foc, *or* du tourmentin
Fore topgallant mast, petit mât de perroquet
Fore topmast, petit mât de hune
Fore topmast stay, étai du petit hunier
Fore topsail braces, bras du petit hunier
Foundation plate, plaque de fondation
Four-way cock, robinet à quatre fins
Frame, couple
Framing, bâtis *or* charpente
Funnel, cheminée en tôle
Furnace, fourneau, foyer
Futtock, allonge
Gaff, pic, corne d'artimon
Gaff topsail, flèche-en-cul
Gallant mast, mât de perroquet
Gallant sail, voile de perroquet
Galvanised iron, fer galvanisé
Gammoning, liure
Garboard strake, virure de gabord
General drawing, dessin d'ensemble
Girder, poutre
Girt, ceintré
Goose-neck, cou de cygne
Grapnel, grappin
Graving dock, forme de radoub
Grummet, estrope
Gunboat, chaloupe canonnière
Gun carriage, affût
Gun metal, bronze de canon
Gun port, sabord
Gunwale, plat-bord
Guy, cordage de retenue
Half-breadth plan, plan horizontal
Halliard, drisse
Hammock, hamac
Hand pump, pompe à bras
Handspike, anspect

ENGLISH INTO FRENCH (continued).

Hard a-lee, lof tout
Hard a-port, la barre toute à bâbord
Hard a-starboard, la barre à tribord toute
Hard a-weather, la barre toute au vent
Harpings, préceintes renforcées de l'avant
Hatch, panneau
Hatchway, écoutille
Hawse pipes, plombs des écubiers
Hawse plug, tampon des écubiers
Hawser, aussière
Head sails, voiles de l'avant
Helm, gouvernail
Hemp, chanvre
High water, pleine mer
Hinge, penture, gond
Hog, goret d'un navire
Hold, cale
Hoop iron, feuillard, fer à ruban
Horse box, wagon-écurie
Horse power, cheval de vapeur
Hounds, jottereaux
Hulk, ponton, cayenne
Hull, corps, coque d'un navire
Hydraulic press, presse hydraulique
Intercostal, entre les côtes
Iron, fer
Iron frame, couple en fer
Iron keel, quille en fer
Iron plate, tôle
Iron rigging, gréement en fer
Iron ship, navire en fer
Iron side, bras de fer
Iron wire, fil de fer
Iron work, ferrure
Jack, cric, cric à vis
Jaw of a boom, mâchoire d'une bôme
Jib, foc
Jolly boat, petit canot
Jump joint, bout à bout
Junk, jonque chinoise
Kedge anchor, ancre à jet
Keel, quille
Keelson, carlingue
Kingston's valve, soupape du navire
Knee, courbe, genou
Knight-heads, bouts des apôtres, bittons
Knot, nœud, bouton
Ladder, échelle
Lap or cover, recouvrement
Lapped joint, joint superposé, joint à clin
Larboard, bâbord
Lashing, aiguillette, fouet
Lateen sail, voile latine
Lateen yard, antenne
Lathe, tour
Launch, avant-cale
Lead, plomb
Leak, fuite, voie d'eau
Leeboard, semelle de dérive
Lee side, côté sous le vent
Leech rope, ralingue de chute
Leeward, côté sous le vent
Leeway, dérive
Life buoy, bouée de sauvetage
Lighter, allége, barque
Limber hole, anguiller
Lock chamber, sas à écluse
Lock gate, porte d'écluse
Locker, équipet
Lower rigging, haubans et étais des bas mâts
Lower yards, basses vergues
Lug sail, voile de lougre
Main, grand
Main mast, grand mât
Main royal mast, grand mât de cacatois
Main royal sail, grand cacatois
Main sail, grand voile
Main sheet, écoute de la grande voile
Main shrouds, grands haubans
Main topgallant mast, grand mât de perroquet

ENGLISH INTO FRENCH (continued).

Main topgallant sail, grand perroquet
Main topgallant staysail, voile d'étai de grand perroquet
Main topmast, grand mât de hune
Main topmast stay, étai du grand mât de hune
Main topsail, voile du grand hunier
Main topsail yard, vergue du grand hunier
Man-hole, trou d'homme
Man-of-war, bâtiment de guerre
Man-rope, garde-corps
Marine boiler, chaudière marine
Marine engine, machine à vapeur marine
Marine glue, colle marine
Master shipwright, premier ingénieur-constructeur d'un port
Merchantman, navire de commerce
Merchant service, marine marchande
Messenger, tournevire
Metacentre, métacentre
Midships, milieu du navire
Mizen, artimon
Mizen mast, mât d'artimon
Mizen sail, voile d'artimon
Mizen shrouds, haubans d'artimon
Mizen staysail, benjamine
Mizen topgallant mast, mât de perruche
Mizen topgallant staysail, voile d'étai de perruche
Mizen topmast staysail, diablotin
Moorings, corps-mort
Mould, gabari
Mould loft, salle des gabaris
Mud hole, trou de sel
Nail, clou
Neap tide, morte-eau
Netting, filet de bastingage
Nut, tenon
Oakum, étoupe
Oar, aviron
Orlop, entrepont
Orlop deck, faux pont
Outrigger, aiguille de carène
Paddle beam, bau de force
Paddle box, tambour
Paddle float, aube
Paddle wheel, roue à aubes
Palm, patte d'ancre
Parrel rope, bâtard de racage
Partner, étambrai
Paunch, natte
Pendant, flamme, banderole
Pig iron, gueuse
Pinnace, pinasse, canot
Pintle, aiguillot
Pitch, poix, brai sec
Pitch chain, chaîne à la Vaucanson
Plank, bordage, planche
Pole, pôle, bâton
Pole mast, mât à pible
Pontoon, ponton de carénage
Port helm, bâbord la barre
Port lid, mantelet de sabord
Port sill, seuillet de sabord
Post, poteau
Preventer stay, faux étai
Propeller, propulseur
Propelling screw, hélice propulsive
Propelling screw-shaft, arbre d'hélice
Pulley, poulie, rouleau
Pump, pompe
Pump handle, brinqueballe
Punt, acon, pont flottant
Quadrant, octant
Quarter deck, gaillard d'arrière
Quay, quai
Rabbet, râblure
Rake, inclinaison
Ratchet brace, cliquet à percer
Ratline, enfléchure
Reef, récif, ris
Relieving tackles, palans de carène

ENGLISH INTO FRENCH (continued)

Repair, radoub
Rib, membre, rame
Riband, lisses des couples
Rig (to), gréer
Rigging, gréement, manœuvres
Ring bolt, cheville à boucle
Rivet, rivet
Rivet (to), river
Rolling mill, laminoir
Rope, corde, cordage
Rope yarn, fil de caret
Rough-tree rail, lisse de batayoles
Rowlocks, toletières
Royal mast, mât de cacatois
Royal sail, cacatois
Royal yard, vergue de cacatois
Rudder, gouvernail
Running rigging, manœuvres courantes
Safety valve, soupape de sûreté
Sail, voile
Sail of a lugger, bourcet
Sampson's post, épontille
Scantlings, échantillons
Scarf, écart, empâture
Schooner, goëlette
Screw jack, vérin, cric à vis
Screw propeller, hélice propulsive
Scupper, dalot
Scuttle, écoutille, hublot
Seaman, matelot
Shackle, manicle
Shaft, arbre
Sheathing, doublage
Sheave, rouet de poulie
Sheer, tonture
Sheer draught, plan d'élévation
Sheer-legs, bigue, chèvre
Sheet anchor, ancre de miséricorde
Shipwreck, naufrage
Shipwright, charpentier de navire
Shrouds, haubans
Side scuttle, hublot
Signal flag, pavillon de signal
Skin, bordage
Skylight, écoutille vitrée
Skyscraper, aile de pigeon
Sling of a yard, suspente
Smack, semaque
Sounding lead, plomb de sonde
Sounding line, ligne de sonde
Sounding rod, sonde de pompe
Spanker, voile d'artimon
Spar, espar, mâtereau, montant
Spar deck, pont sur montant
Spindle, tige, mèche, broche
Spirit room, cale au vin
Spirketting, feuilles bretonnes
Splice, épissure
Spoke, rayon d'une roue
Sprit sail, voile de civadière
Square sail, voile carrée
Staging, échafaudage
Stanchion, épontille, montant
Standard, courbe, verticale
Standing rigging, manœuvres dormantes
Stand pipe, tuyau alimentaire à colonne d'eau
Staple, crampe de fer
Starboard, tribord
Starting gear, mise en marche
Stay, étai, relâche
Steam engine, machine à vapeur
Steamer, vapeur
Steam frigate, frégate à vapeur
Steel, acier
Steer (to), gouverner
Steering wheel, roue du gouvernail
Stem, étrave
Step of the mast, carlingue du mât
Stern, poupe, arrière
Stern frame, arcasse
Stern post, étambot
Steward's room, cambuse
Stock of an anchor, jas d'ancre
Stoke hole, parquets des chauffeurs
Store room, soute

ENGLISH INTO FRENCH (concluded).

Stores, provisions
Stowage, arrimage
Strake, virure
Strap, chape, courroie, bride
Stream anchor, ancre de touée
Stuffing box, presse-étoupe
Studding sail, bonnette
Studding sail boom, bout dehors
Suction pipe, tuyau d'aspiration
Suit of sails, jeu de voile
Swab, faubert
Swivel, tourniquet en fer
Tackle, palan
Tarpaulin, bagnolet
Tee iron, fer en T
Telescope, longue-vue
Tell-tale, axiomètre
Template, gabari
Thimble, cosse en fer [corne
Throat halliard, drisse d'une
Throttle valve, papillon registre
Thwart, banc de nage
Tide, marée
Tie bar, tirant
Tie beam, entrait
Tier of a cable, bitture
Tiller, barre du gouvernail
Tiller rope, drosse du gouvernail
Tilt hammer, martinet, marteau à bascule
Tonnage, tonnage
Top, hune [roquet
Topgallant mast, mât de per-
Topping lift, balancine de gui
Top mast, mât de hune
Top sail, hunier
Topsail yard, vergue de hune
Tow rope, grelin
Trail board, frise de l'éperon
Transom, barre d'arcasse
Transport, transport
Trestle trees, barres des hunes
Trim, assiette, allure, arrimage
Truck, pomme, roue, cosse
Trunnions, tourillons
Truss, drosse de racage
Try sail, voile de senau
Tubular boiler, chaudière tubulaire
Tug boat, remorqueur
Tumble-home, rentrée
Tun, tonneau
Universal joint, joint universel
Upper deck, franc tillac
Upper works, œuvres mortes
Uptake, culotte
Vane, girouette
Vangs, palans de retenue, bras de bôme
Vessel, navire, bâtiment
Victuals, vivres, approvisionnements
Wake, sillage, eaux, houache
Wale, préceinte
Ward room, grande chambre
Warp, câblot, grelin, touée
Warped plank, bordage déjeté
Wash boards, fargues
Water line, ligne d'eau
Water tank, caisse à eau
Water-tight bulkhead, cloison étanche
Water-tight compartment, compartiment étanche
Water-way, gouttière
Wave, vague, lame
Weather bow, bossoir du vent
Weather braces, bras du vent
Weatherly ship, navire bon boulinier
Wharf, quai
Wheel, roue
Whelps of capstan, flasques du cabestan
White lead, blanc de céruse
Winch, moulinet, virevaut
Windlass, guindeau, virevaut
Windward, au vent
Workmanship, main-d'œuvre
Wreck, naufrage
Yard, vergue
Yard arm, bout de vergue
Yarn, fil de caret
Yawl, yole, moyen canot

VOCABULARY OF TECHNICAL TERMS USED IN SHIPBUILDING.

FRENCH—ENGLISH.

A bord, aboard
About, butt, end part
Aboutement, scarf
Accastillage, upper works
Acier, steel
Acier fondu, cast steel
Acier poule, blister steel
Acon, punt, flat
Affût, gun carriage
A flot, afloat, floating
Aguiée, cringle
Aiguillette, lashing, laniard
Aile d'hélice, blade of a screw
Aile de pigeon, skyscraper
Aillure, carling
A l'arrière, astern
Allège, lighter, barge
Allonge, futtock
Allure, trim
Aman, halliard
Amiral, admiral
Amirauté, admiralty
Ancre, anchor
Ancre du bossoir, bower anchor
Ancre de miséricorde, sheet anchor
Angle, quoin
Angle oblique, bevel
Anguillers, limber holes
Anspect, handspike
Antenne, lateen yard
Apostis, gunwale
Appareil distillatoire, distilling apparatus
Approvisionnements, victuals, naval stores
Arbre, shaft, mast
Arbre à manivelle, crank shaft
Arbre d'hélice, screw propeller shaft
Arcasse, stern frame
Arc-boutant, boom
Arrière, abaft, aft, stern
Arrimage, stowage, trimming
Artimon, mizen sail
Assemblage, framing, scarfing
Assiette, trim
Aube, paddle float
Aube articulée, feathering paddle
Au milieu du navire, amidships
Au vent, windward
Avant, bow, forward
Avant-cale, launch, slip
Avant d'un vaisseau, bow of a vessel
Aviron, oar
Axiomètre, tell-tale
Azimut, azimuth
Bâbord, larboard
Bâbord la barre, port the helm
Bagnolet, tarpaulin
Baille, bucket
Baisse, ebb tide
Balancine, lift
Balancine de corne, topping lift
Balancine de gui, topping lift
Balaou, schooner
Baleinière, whale boat
Banc, seat
Banc de nage, thwart
Banderole, pendant
Barbette, gunwale
Barque, barque
Barre, helm, tiller, cross-tree
Barre d'arcasse, transom
Barre de hune, trestle tree
Barre du gouvernail, tiller
Basses vergues, lower yards
Basse voile, course
Bassin, shipping, dock
Bâtard de racage, parrel rope
Bâtardeau, coffer-dam
Bateau, boat, craft, barge
Bateau de passage, ferry boat
Bateau-porte, caisson

FRENCH INTO ENGLISH (continued).

Bâtiment, vessel, ship
Bâtiment de guerre, man-of-war
Bâton, head, mast, pole
Bau, beam
Bau de force, paddle beam
Bauquière, clamp
Beaupré, bowsprit
Benjamine, mizen staysail
Berceau, cradle
Bigue, sheer-legs
Bittes, bitts
Bittons, knight-heads
Blanc de céruse, white lead
Bôme, boom
Bonnette, studding sail
Bordage, plank, skin
Bordage déjeté, warped plank
Bordage mince, deal
Bordages des ponts, deck planks
Bosse à bouton, deck stopper
Bossoir, cat-head
Bossoir du vent, weather bow
Bouée, buoy
Bouée de sauvetage, life buoy
Boulon, bolt, pin
Bourcet, sail of a lugger
Boussole, compass
Bout, butt, end
Bout à bout, jump joint
Bout dehors, studding-sail boom
Bout dehors de clinfoc, flying jibboom
Bout de vergue, yard arm
Bouts des apêtres, knight-heads
Brai, pitch
Bras, brace, arm
Bras de bôme, vangs
Bras de fer, iron side
Bras du petit hunier, fore topsail braces
Bras du vent, weather braces
Brasse, fathom
Bride, strap
Brig, brig
Brigantin, brigantine
Brigantine, spanker, driver
Brinqueballe, pump handle
Brisant, breaker
Broche, spindle
Bronze, brass
Bronze de canon, gun metal
Brûlot, fire ship
Cabane, cabin
Cabestan, capstan
Cabine, cabin
Câble, cable
Câblot, warp, painter.
Cabotage, coasting trade
Cabotier, coasting vessel
Cabrion, whelp
Cacatois, royal sail
Cache-adent, scarf
Caillebottis, grating
Caisse à eau, water tank
Caisson, chest, locker
Cale, hold
Cale au vin, spirit room
Calfat, caulker
Calfater, to caulk
Cambuse, steward's room
Canonnière, gunboat
Canot, boat, yawl
Cap de mouton, dead-eye
Capitaine de frégate, commander
Capon, cat block, cat hook
Capot d'échelle, companion
Carène, careen
Cargaison, cargo
Cargue, brail, garnet
Cargues-points, clew garnets
Carlingue, keelson, engine-bearer
Carlingue du mât, step of the mast
Carré, square-rigged
Carreau, gunwale of a boat
Caveau, store room
Chaîne, chain
Chaîne à la Vaucanson, pitch chain
Chaîne sans fin, endless chain
Chambre, cabin
Chambre de la machine, engine room
Chanvre, hemp

FRENCH INTO ENGLISH (continued).

Chargement, cargo
Charpente, framing
Charpentier, carpenter, shipwright
Chaudière marine, marine boiler
Chaudière tubulaire, tubular boiler
Chaudronnier, boiler maker
Cheval-vapeur, horse power
Cheville, bolt
Cheville à boucles, ring bolt
Cheville à œillet, eye bolt
Chèvre, crane, sheer-legs
Clapet, clack valve
Clapet de décharge, delivery valve
Clinfoc, flying jib
Cliquet à percer, ratchet brace
Cloche, bell
Cloison, bulkhead
Cloison étanche, water-tight bulkhead
Clou, nail
Coittes, bilge ways
Colle marine, marine glue
Collerette, flange
Collet, flange
Compartiment étanche, water-tight compartment
Compas de route, compass
Compas de variation, azimuth compass
Comput, calculation
Constructeur, builder
Contre-étambot, back of stern [post
Contre-étrave, apron
Coque d'un navire, hull
Cordage, rope, rigging
Corde, rope
Corne, throat, peak
Corne d'artimon, gaff
Cornière, angle iron
Corps, hull
Corps flottant, floating body
Corps-mort, bollards
Corvette, corvette, sloop of war
Cosse, truck, thimble
Côté, side, broadside
Côté sous le vent, lee side
Cou de cygne, goose-neck
Couleurs, ship's flag, colours
Couple, frame, timber
Couple en fer, iron frame
Couples dévoyés, cant timbers
Courbaton, bracket
Courbe, knee, standard
Couronnement, taffrail
Cours, strake
Crampe de fer, iron staple
Crapaud, goose-neck
Crapaudine, bed plate
Creux, depth
Creux de cale, depth of hold
Cric à vis, screw jack
Croiseur, cruiser
Cuisine, galley
Cuivre, copper
Cul, poop, after part, stern
Cure-môle, dredging machine
Cutter, cutter
Dalot, scupper
Darse, dock
Davier, davit
Débarquement, unloading
Défense, fender
Dérive, leeway
Dessin d'ensemble, general drawing
Diablon, mizen topgallant staysail
Diablotin, mizen topmast staysail
Doublage, sheathing
Doublé en cuivre, copper-bottomed
Drisse, halliard
Drisse d'une corne, throat halliard
Drisse de la trinquette du petit foc, fore staysail halliard
Drisse de racage, truss
Drisse du gouvernail, tiller rope
Drisse du grand hunier, main topsail halliard

FRENCH INTO ENGLISH (continued).

Drisse du petit perroquet, fore topgallant sail halliard
Dunette, poop
Eaux, wake
Ebbe, ebb tide
Ecart, scarf
Echafaudage, staging
Echantillon, scantling
Echarpe, head rail
Echelle, ladder
Ecluse, dock
Ecoute, sheet
Ecoute de la grande voile, main sheet
Ecoutille, hatchway, scuttle
Ecoutille vitrée, skylight
Egouttoir, grating
Elancé, flare, projecting
Elévation, elevation
Elongis, trestle trees
Emergé, buoyant
Empâture, scarf
Emplanture, step
Enclaver, to mortise
Encouturé, clinched
En-dessous, after part
En-dessus, fore part
Enfléchure, rat line
Engraver, to trim, to stow
Enseigne, flag, ensign
Entrait, tie beam
Entre les côtés, intercostal
Entremise, carling
Entrepont, between-decks, orlop deck
Entretoise, transom, partner
Eperon, head, cutwater
Epissure, splice
Epontille, stanchion, pillar
Epontille, Sampson's post
Equerre, bevel, movable square
Equipet, locker
Espars, spars
Etai, stay
Etai du grand mât de hune, main topmast stay
Etai du petit hunier, fore topmast stay
Etai et faux, fore stay
Etambot, stern post
Etambrai, partner
Etance, Sampson's post
Etanche, tight
Etancher, to free from water
Etoupe, oakum
Etrave, stem
Façons, run, rising floor
Fardage, dunnage
Fargues, wash-boards
Faubert, swab
Fausse quille, false keel
Faux baux, orlop beams
Faux bras, preventer braces
Faux étai, preventer stay
Faux mantelet, dead-light
Faux pont, orlop deck
Fer, iron
Fer à ruban, hoop iron
Fer d'angle, angle iron
Fer en barres, bar iron
Fer en T, tee iron
Fer galvanisé, galvanised iron
Ferrure, iron work, hinge
Feuillard, hoop iron
Feuilles bretonnes, spirketting
Fil de caret, rope yarn
Fil de fer, iron wire
Filet, netting
Filet de bastingage, netting
Flamme, pendant
Flasques, whelps cheeks
Flèche, skyscraper mast, boom, prow
Flèche-en-cul, gaff, topsail
Flottaison, water line
Flottant, afloat
Foc, jib
Foc d'artimon, mizen staysail
Fond, bottom, hold, floor
Fonte de fer, cast iron
Foret, drill
Forme de radoub, dry dock
Forme flottante, wet dock

FRENCH INTO ENGLISH (continued).

Forme sèche, dry dock
Fort, extreme breadth
Fortune, fore sail, lug sail
Fosse, pit, store room
Fosse aux câbles, cable tier
Fouet, laniard, lashing
Fourcats, crutches
Fourche, sheers
Fourneau, furnace
Fraîcheur, cat's-paw
Frais, breeze, wind
Fraisure, countersink
Franc tillac, upper deck
Frégate à vapeur, steam frigate
Frise de l'éperon, trail board, frieze
Funé, rigged
Fût, cask
Gabari, mould, template
Gabet, vane
Gabord, garboard strake
Gaffe, boat hook
Gaillard d'arrière, quarter deck
Gaillard d'avant, forecastle
Galhauban, back stay
Gambes, futtock shrouds
Garant, fall, running
Garant de la candelette, fish-tackle fall
Garde-corps, man rope
Gatte, manger
Genou, knee
Girouette, vane
Gisole, binnacle
Goëlette, schooner
Gond, hinge
Goret, hog
Gorgère, cutwater
Gournable, tree nail
Gouttière, water-way
Gouvernail, rudder, helm
Gouverner, to steer
Grand, main
Grand cacatois, main royal sail
Grand foc, main topmast stay-sail
Grand hunier, main topsail
Grand mât, main mast
Grand mât de cacatois, main royal mast
Grand mât de hune, main top-mast
Grand mât de perroquet, main topgallant mast
Grand perroquet, main top-gallant sail
Grande chambre, ward room
Grande hune, main top
Grande vergue, main yard
Grande voile, main sail
Grande voile d'étai, main staysail
Grande voûte, counter
Grands haubans, main shrouds
Grappin, grapnel
Gréage, rigging
Gréement, rigging
Gréement en fer, iron rigging
Gréer, to rig
Grelin, warp, tow rope
Gros de l'eau, high water
Grue, crane, windlass
Gué, ferry
Guindeau, windlass
Guirlande, breast hook
Guitran, pitch
Habitacle, binnacle
Hale-bas, down-haul
Hamac, hammock
Hampe, handle
Haubans, shrouds
Haubans et étai des bas mâts, lower rigging
Havre, harbour
Heaume, tiller
Hélice propulsive, screw pro-peller
Herminette, adze
Hêtre, beech
Houache, wake, track
Hublot, side scuttle
Hune, top
Hunier, top sail
Inclinaison, rake, dip, heeling,-stive

FRENCH INTO ENGLISH (continued).

Inventaire, inventory
Jambe de chien, stem timber
Jas d'ancre, anchor stock
Jeu de voiles, suit of sails
Joint à clin, lapped joint
Joint à collet, flange joint
Joint superposé, lapped joint
Joint universel, universal joint
Jottereaux, cheeks, hounds
Jouet, iron plate
Jusant, ebb tide
Kot, awning, canopy
La barre à tribord toute, hard a-starboard
La barre toute à bâbord, hard a-port
La barre toute au vent, hard a-weather
Lame, wave
Laminoir, rolling mill
Lanche, launch
Largeur, breadth
Léger, light, buoyant
Lest, ballast
Levée, swell, surge
Liaisons, strengthening pieces
Ligne d'eau, water line
Ligne de sonde, sounding line
Lisse de batayoles, rough-tree rail
Lisse de fort, extreme breadth line
Lisse d'éperon, head rail
Lisses des couples, ribands
Lisses des façons, rising of the floor
Lit, bed, berth
Liure, gammoning
Livarde, sprit of a shoulder of mutton sail
Lof tout, hard a-lee
Longue-vue, telescope
Lougre, lugger
Lumière, limber hole
Lunette, telescope
Machine, engine
Machine à cintrer les tôles, bending press
Machine à draguer, dredging machine
Machine à percer, drilling machine
Machine à vapeur marine, marine engine
Main-d'œuvre, workmanship
Mâchoire d'une bôme, jaw of a boom
Maître d'équipage, boatswain
Manicle, shackle
Manivelle, handle
Manœuvres, rigging
Manœuvres courantes, running rigging
Mantelet de sabord, port lid
Marbre, steering-wheel barrel
Marée, tide
Marguerite, messenger
Mariage, lashing
Marie-salope, mud barge
Marine marchande, merchant service
Marsouin, stemson
Martinet, peak halliard
Martingale, bobstay
Mât, mast
Mât à pible, pole mast
Mât d'artimon, mizen mast
Mât de cacatois, royal mast
Mât de grand perroquet, main topgallant mast
Mât de hune, topmast
Mât de misaine, fore mast
Mât de perroquet, topgallant mast
Mât de perruche, mizen topgallant mast
Mâtereau, small mast, spar
Mâteur, mast maker
Mèche, spindle, barrel
Mèche du cabestan, capstan barrel
Métacentre, metacentre
Milieu du navire, midships
Misaine, fore sail
Mise en marche, starting gear
Mitraille, case shot

FRENCH INTO ENGLISH (continued).

Modèle, model, mould
Moise, cross beam, cross-tree
Molle mer, slack water
Montant, stanchion
Moque, dead-eye, heart
Mortaise, mortise
Morte eau, neap tide
Moulage, moulding
Moulinet, winch
Moulure, moulding
Moustaches, standing lifts
Natte, paunch
Naufrage, shipwreck
Nautique, nautical
Naval, naval
Navire, vessel, ship
Navire bon boulinier, weatherly ship
Navire de commerce, merchant-man
Navire en fer, iron ship
Nocher, boatswain
Nœud, hitch, bend, knot
Noix, hound
Nolis, freight
Nuaison, steady wind
Oblique, cant, slant
Obusier, howitzer
Octant, quadrant
Œillet, eye, cringle
Œuvre, free-board
Œuvres mortes, upper works
Office, pantry
Oreille, fluke
Ourse, vang, mizen boom
Pagaye, paddle
Paille-en-cul, driver
Paillet, paunch
Paillot, bread room
Palan, tackle, burton, halliard
Palans de carène, relieving tackles
Palans de retenue, vangs
Palme, palm
Panneau, hatch cover
Pantoire de la candeletto de l'ancre, fish pendant
Papillon, skyscraper
Papillon registre, throttle valve
Paracloses, limber boards
Par le travers, athwart
Parquets des chauffeurs, stoke hole
Passager, passenger
Passeresse, brail
Patren de chaloupe, cockswain
Patto, palm, fluke
Pavillon, flag, colours
Pavillon de détresse, signal flag
Pavillon de poupe, ensign
Payeur, paymaster
Peinture, paint
Pène, mop
Penture, hinge
Perpigner, to set the frames
Perroquet, topgallant sail
Perroquet de fougue, mizen topsail
Perruche, mizen topgallant sail
Petit, fore top
Petit foc, flying jib
Petit fond d'un navire, bilge of a ship
Petit mât de cacatois, fore royal mast
Petit mât de hune, fore topmast
Petit mât de perroquet, fore top-gallant mast
Petite brise, cat's-paw
Pic, peak
Pied, shoe, forefoot, heel
Pinasse, pinnace
Pique d'abordage, boarding pike
Plan vertical, body plan
Plaque d'écart de tôle, butt cover
Plaque de fondation, foundation plate
Plaque de jonction, butt cover
Plastrons, knight-heads
Plat-bord, gunwale
Pleine mer, high water
Plus grande largeur, breadth extreme

FRENCH INTO ENGLISH (continued).

Point d'écoute, clew
Pompe, pump
Pompe à air, air pump
Pompe à bras, hand pump
Pompe alimentaire, feed pump
Pompe de cale, bilge pump
Pont, deck, stage
Pont entier, flush deck
Pont principal, weather deck
Ponton, pontoon
Port, burden, tonnage
Porte d'écluse, lock gate
Pouillousse, main staysail
Poulie, block, pulley
Poutre, girder
Préceinte, wall, rail
Presse-étoupe, stuffing-box
Presse hydraulique, hydraulic press
Presson, crow-bar
Propulseur, propeller
Proue, prow, bow, head
Pyroscaphe, steamer
Quai, quay, wharf
Quille, keel
Quille en fer, iron keel
Quintelage, ballast
Raban, earring, gasket
Râblure, rabbet
Racage, parrel, truss
Radeau, raft
Radier, apron
Radoub, repair
Ralingue, bolt rope
Ralingue de chute, leech rope
Rame, oar
Rasé, dismasted
Rayon, spoke
Récif, reef, ridge
Reflux, ebb tide
Relâche, stay
Remorqueur, tug boat
Remplissage, filling piece
Renflement, bluff
Renfort, lining, binding
Rentrée, tumble-home
Résistance, resistance
Ressac, surf
Retenue, relieving tackle
Revers, flare, hollow
Ribord, garboard strake
Ride, laniard
Ris, reef
Risade, reefing
Risson, grappling
Rivet, rivet
Rivet à tête fraisée, flush rivet
Rivière, river
Robinet à quatre fins, four-way cock
Roue, wheel
Roue à aubes, paddle wheel
Roue à aubes articulées, feathering paddle-wheel
Roue de poulie, sheave
Roue du gouvernail, steering wheel
Rouf, canopy
Rouleau, pulley
Royaux, royal sails
Sabord, gun port
Sainte-barbe, gun room
Salle, loft
Salle des gabaris, mould loft
Sapin, fir wood
Semaque, smack
Semelle de dérive, leeboard
Seuillet de sabord, port sill
Sillage, wake, steerage
Sonde de pompe, sounding rod
Soupape de sûreté, safety valve
Soupape du navire, Kingston's valve
Sous-barbe, bobstay
Soute, bunker, store room
Soute au pain, bread room
Stabilité, stability, stiffness
Suspente, sling of a yard, guy, straps
Tableau, after part of a ship
Taille-mer, cutwater
Taille-vent, main sail of a lugger
Talonnière, heel of the rudder

FRENCH INTO ENGLISH (concluded).

Tambour, drum, washboard, paddle-box
Tambour de la roue du gouvernail, barrel of the steering wheel
Tampon des écubiers, hawse plug
Tapecul, ringtail sail, driver
Taquet, cleat, clamp
Tarière, auger
Teck, teak
Tenon, tenon, nut
Tente, awning
Tête, upper end, head
Tête d'un couple, butt
Tête de varangue, floor head
Tête fraisée, countersunk head
Théâtre, cockpit
Tierçon, tierce
Tige, spindle
Tillac, deck
Tille, platform
Tirant d'eau, draught of water
Toile à voiles, sail cloth, canvas
Tôle, boiler plate, iron plate
Toletière, rowlock
Ton, mast-head, cop
Tonnage, tonnage
Tonne, ton, butt, cask
Tonneau, tun, 1,000 kilogrammes
Tonture, sheer, round up
Torpédo, torpedo
Touée, warp, tow line
Tourillons, trunnions
Tourmentin, fore staysail
Tournevire, messenger
Tourniquet, roller, swivel
Transport, transport
Tréou, lug sail
Treuil, crab winch
Tribord, starboard
Tringle, cant
Trinquet, fore mast
Trinquette, fore staysail
Trois-mâts, three-masted vessel
Trois-ponts, three-decker
Trou, shelter, harbour
Trou de sel, mud-hole
Trou d'homme, man-hole
Tuyau alimentaire à colonne d'eau, stand-pipe
Tuyau d'aspiration, suction pipe
Tuyau d'écoulement, delivery pipe
Tuyau en fonte, cast-iron pipe
Uretac, winding tackle
Vague, wave, sea
Vaigrage, walling, ceiling, lining
Vaisseau, ship, vessel
Vapeur, steamer
Varangue, floor timber
Vareuse, sail cloth
Vassole, coaming
Vent, wind, breeze
Ventilateur, wind sail
Vergue, yard, peak, boom
Vergue de cacatois, royal yard
Vergue de hune, topsail yard
Vergue du grand hunier, main topsail yard
Vérin, screw jack
Verticale, standard
Vindas, windlass
Virevaut, crab winch
Virure, strake
Virure de gabord, garboard strake
Voile, sail
Voile carrée, square sail
Voile d'artimon, spanker
Voile de civadière, sprit sail
Voile d'étai de grand perroquet, main topgallant staysail
Voile d'étai de perruche, mizen topgallant staysail
Voile de l'avant, head sail
Voile de senau, try sail
Voile latine, lateen sail
Voûte, counter
Wagon-écurie, horse box
Yole, yawl
Youyou, gig
Zinc, zinc

ENGLISH WEIGHTS AND MEASURES.

Avoirdupois Weight.

Drams	Ozs.	Lbs.	Qrs.	Cwts.	Ton	Grammes
1	·0625	·0039063	·0001395	·0000349	·00000174	1·771846
16	=1	·0625	·0022321	·000558	·00002790	28·34954
256	16	=1	·0357143	·0089285	·00044643	453·5927
7168	448	28	=1	·25	·0125	12700·59
28672	1792	112	4	=1	·05	50802·38
573440	35840	2240	80	20	=1	1016048

A stone of iron, coal, &c. = 14 lbs.

Troy Weight.

Avoir. Drs.	Grains	Dwts.	Ozs.	Lbs.	Grammes
32 ÷ 875	=1	·0416667	·0020833	·0001736	·0648
768 ÷ 875	24	=1	·05	·0041667	1·5552
17 + (97 ÷ 175)	480	20	=1	·0833333	31·1035
210 + (114 ÷ 175)	5760	240	12	=1	373·2420

175 lbs. Troy = 144 lbs. Avoir.
175 oz. Troy = 192 oz. Avoir.
Avoir. lbs. × 1·21527 = lbs. Troy.
Troy lbs. × ·823 = Avoir. lbs.

Lineal Measure.

Inches	Feet	Yards	Faths.	Poles	Furls.	Mile	Metres
1	·08333	·02778	·013889	·005051	·000126	·000016	·0254
12	=1	·33333	·166667	·060606	·001515	·000189	·304797
36	3	=1	·5	·181818	·004545	·000568	·914392
72	6	2	=1	·363636	·009091	·001136	1·82878
198	16½	5½	2¾	=1	·025	·003125	5·02915
7920	660	220	110	40	=1	·125	201·166
63360	5280	1760	880	320	8	=1	1609·33

The palm = 3 in.
The hand = 4 in.
The span = 9 in.
The cubit = 18 in.
The common military pace = 30 in.
An itinerary pace = 5 feet.
A cable's length = 120 fathoms.
A league = 3 miles.

Land Measure (Lineal).

Inches	Links	Feet	Yards	Chains	Mile	Metres
1	·1261261	·0833333	·0277778	·0012626	·0000158	·0254
$7\frac{23}{25}$	=1	·6666667	·2222222	·01	·000125	·201166
12	$1\frac{17}{33}$	=1	·3333333	·0151515	·0001894	·304797
36	$4\frac{6}{11}$	3	=1	·0454545	·0005682	·914392
792	100	66	22	=1	·0125	20·1166
63360	8000	5280	1760	80	=1	1609·33

Square Measure.

Inches	Feet	Yards	Perches	Roods	Acre	Sq. Metres
1	·0069444	·0007716	·0000255	·00000064	·00000016	·0006452
144	=1	·1111111	·0036731	·0000918	·000023	·0929013
1296	9	=1	·0330579	·0008264	·0002066	·836112
39204	$272\frac{1}{4}$	$30\frac{1}{4}$	=1	·025	·00625	25·292
1568160	10890	1210	40	=1	·25	1011·696
6272640	43560	4840	160	4	=1	4046·782

Acres × ·0015625 = sq. miles. Sq. yards × ·000000323 = sq. miles.

Land Measure (Square).

Links	Perches	Chains	Roods	Acre	Sq. Metres
1	·0016	·0001	·00004	·00001	·04046
625	=1	·0625	·025	·00625	25·292
10000	16	=1	·4	·1	404·6782
25000	40	$2\frac{1}{2}$	=1	·25	1011·696
100000	160	10	4	=1	4046·782

A hide of land = 100 acres. A yard of land = 30 acres.
A chain wide = 8 acres per mile.

Cubic Measure.

Imperial Gallons	Cub. Ins.	Cub. Feet	Cub. Yds.	Cub. Metre
·003606540822	=1	·0005788	·00000214	·000016387
6·232102541168	1728	=1	·0370370	·0283161
168·266768641554	46656	27	=1	·764534

A cubic yard of earth = 1 load. A barrel bulk = 5 cub. ft.
Ton of displacement of a ship = 35 cub. ft. = ·9910624 cub. metre.

Wine Measure.

Cub. Ins.	Gills	Pints	Quarts	Gallons	Ankers	Runlets	Barrels	Tierces	Hogsheads	Puncheons	Pipes or Butts	Tun
$8·664\frac{13}{16}$	=1											
$34·659\frac{1}{4}$	4	=1										
$69·318\frac{1}{2}$	8	2	=1									
277·274	32	8	4	=1								
2772·740	320	80	40	10	=1							
4990·932	576	144	72	18	$1\frac{4}{5}$	=1						
8734·131	1008	252	126	$31\frac{1}{2}$	$3\frac{3}{20}$	$1\frac{3}{4}$	=1					
11645·508	1344	336	168	42	$4\frac{1}{5}$	$2\frac{1}{3}$	$1\frac{1}{3}$	=1				
17468·262	2016	504	252	63	$6\frac{3}{10}$	$3\frac{1}{2}$	2	$1\frac{1}{2}$	=1			
23291·016	2688	672	336	84	$8\frac{2}{5}$	$4\frac{2}{3}$	$2\frac{2}{3}$	2	$1\frac{1}{3}$	=1		
34936·524	4032	1008	504	126	$12\frac{3}{5}$	7	4	3	2	$1\frac{1}{2}$	=1	
69873·048	8064	2016	1008	252	$25\frac{1}{5}$	14	8	6	4	3	2	=1

Ale and Beer Measure.

Cub. Ins.	Pints	Quarts	Gallons	Firkins	Kilderkins	Barrels	Hogsheads	Puncheons	Butts	Tuns	Last
34·659$\frac{1}{4}$	=1										
69·318$\frac{1}{2}$	2	=1									
277·274	8	4	=1								
2495·466	72	36	9	=1							
4990·932	144	72	18	2	=1						
9981·864	288	144	36	4	2	=1					
14972·796	432	216	54	6	3	1$\frac{1}{2}$	=1				
19963·728	576	288	72	8	4	2	1$\frac{1}{3}$	=1			
29945·592	864	432	108	12	6	3	2	1$\frac{1}{2}$	=1		
59891·184	1728	864	216	24	12	6	4	3	2	=1	
119782·368	3456	1728	432	48	24	12	8	6	4	2	=1

Corn and Dry Measure.

Cub. Ins.	Pints	Quarts	Pottles	Gallons	Pecks	Bushels	Strikes	Sacks	Quarters	Loads	Last
34·659$\frac{1}{4}$	=1										
69·318$\frac{1}{2}$	2	=1									
138·637	4	2	=1								
277·274	8	4	2	=1							
554·548	16	8	4	2	=1						
2218·192	64	32	16	8	4	=1					
4436·384	128	64	32	16	8	2	=1				
8872·768	256	128	64	32	16	4	2	=1			
17745·536	512	256	128	64	32	8	4	2	=1		
88727·680	2560	1280	640	320	160	40	20	10	5	=1	
177455·360	5120	2560	1280	640	320	80	40	20	10	2	=1

Coal Measure.

Cub. Ins. Heaped Measure	Lbs. Avoir.	Pecks	Bushels	Sacks	Vats or Strikes	Chalds.	Newc. Chalds.	Keels	Scores	Ship Load
703·872	18$\frac{2}{3}$	=1								
2815·487	74$\frac{2}{3}$	4	=1							
8446·461	224	12	3	=1						
25339·383	672	36	9	3	=1					
101357·532	2688	144	36	12	4	=1				
196380·218$\frac{1}{4}$	5208	279	69$\frac{3}{4}$	23$\frac{1}{4}$	7$\frac{3}{4}$	1$\frac{15}{16}$	=1			
1571041·746	41664	2232	558	186	62	15$\frac{1}{2}$	8	=1		
2128508·172	56448	3024	756	252	84	21	10$\frac{26}{31}$	1$\frac{11}{31}$	=1	
31420834·92	833280	44640	11160	3720	1240	310	160	20	14$\frac{16}{21}$	=1

Wool Weight.

Pounds	Cloves	Stones	Tods	Weys	Packs	Sacks	Last
7	=1						
14	2	=1					
28	4	2	=1				
182	26	13	$6\frac{1}{2}$	=1			
240	$34\frac{2}{7}$	$17\frac{1}{7}$	$8\frac{4}{7}$	$1\frac{29}{91}$	=1		
364	52	26	13	2	$1\frac{31}{60}$	=1	
4368	624	312	156	24	$18\frac{1}{5}$	12	=1

Measure of Time.

Seconds	Minutes	Hours	Days	Weeks	Months	Calend. Year	Julian Year	Leap Year
60	=1							
3600	60	=1						
86400	1440	24	=1					
604800	10080	168	7	=1				
2419200	40320	672	28	4	=1			
31536000	525600	8760	365	$52\frac{1}{7}$	$13\frac{1}{28}$	=1		
31557600	525960	8766	$365\frac{1}{4}$	$52\frac{5}{8}$	$13\frac{5}{112}$	$1\frac{1}{1460}$	=1	
31622400	527040	8784	366	$52\frac{2}{7}$	$13\frac{1}{14}$	$1\frac{1}{565}$	$1\frac{1}{487}$	=1

Angular Measure.

The Geographical Division of any Line round the Circumference of the Earth	Diurnal Motion of the Earth reduced to Time
60 seconds = 1 minute	= 4 seconds
60 minutes = 1 degree	= 4 minutes
15 degrees = $\frac{1}{2}$ sign of the zodiac	= 1 hour
30 degrees = 1 sign of the zodiac	= 2 hours
90 degrees = 1 quadrant	= 6 hours
1 revolution or 4 quadrants or 360 degrees = the earth's circumf., or 12 signs = 1 great circle .	= 24 hours

Coke.

4 bushels = 1 sack. 12 sacks = 1 chaldron. 21 chaldrons = 1 score.

Miscellaneous Weights and Measures.

Aume of hock . . . . 31 gals.
Bag of cocoa . . . . 112 lbs.
" coffee . . . . 140 to 168 "
" hops . . . . 280 "
" pepper (black), company's . . . . . . 316 "
" " free-trade bags . . . 28, 56, and 112 "
" " (white) . . . . 168 "
" rice . . . . 168 "
" sago . . . . 112 "

MISCELLANEOUS WEIGHTS AND MEASURES (continued).

Bag of saltpetre (East India)	168 lbs.
" sugar or malt (Mauritius)	112 to 168 "
" " (East India)	112 to 196 "
" biscuits (Admiralty)	102 "
Bale of coffee (Mocha)	224 to 280 "
" cotton wool (Virginia, Carolina, & W. Indies)	300 to 310 "
" " " (New Orleans and Alabama)	400 to 500 "
" " " (East India)	320 to 360 "
" " " (Brazil)	160 to 200 "
" " " (Egyptian)	180 to 280 "
" rags (Mediterranean)	448 to 476 "
Bar of bullion	15 to 30 "
Barrel of raisins	112 "
" soap	256 "
" anchovies	30 "
" coffee	112 to 168 "
" tar	26·5 gals.
" turpentine	224 to 280 lbs.
" flour	220 "
" pork	224 "
Boll of flour	140 "
Box of camphor	112 "
" raisins (Valencia)	30 to 40 "
Bushel of wheat	60 "
" flour	56 "
" rye	58 "
" barley	47 "
" oats	40 "
" oatmeal	51 "
" peas	64 "
" beans	63 "
" rape seed	50 "
" malt	38 "
" salt	56 "
" clover (red)	64 "
" " (white)	62 "
" linseed	52 "
" chicory (raw)	50 "
" " (kiln-dried)	28 "
" " (powdered)	38 "
" coffee (raw)	51·25 "
" " (roasted)	32·25 "
" " (ground)	36 "
" buck wheat	50 to 56 "
" canary seed	53 to 61 "
" hemp "	42 to 44 "
" lentil "	60 to 62 "
" linseed (Bombay)	50 to 52 "

MISCELLANEOUS WEIGHTS AND MEASURES (continued).

Bushel of onion seed	36 to 38 lbs.
" millet "	56 to 64 "
" poppy "	48 "
" rape "	48 to 53 "
" tare "	62 to 66 "
" turnip "	50 to 56 "
" cabbage "	50 to 56 "
Butt of currants	1,680 to 2,240 "
" cadiz	108 gals.
" sherry	108 "
Cask of cocoa	140 lbs.
" mustard	9 to 18 "
" nutmegs	200 "
" rice (American)	672 "
" tallow	1,008 "
Catty of tea	1·33 "
Chaldron of coals	2·63 tons
Chest of tea (Congou) about	82·5 lbs.
" " (Souchong) "	81·0 "
" " (Pekoe) "	65·5 "
" " (Hyson and Hyson skin) about	65 "
" " (Gunpowder) about	109 "
" " (Imperial) about	95·7 "
" " (Young Hyson)	94 "
Cran of herrings	37·5 gals.
Firkin of butter	56 lbs.
" soap	64 "
Hogshead of brandy	45 to 60 gals.
" " rum	45 to 50 "
" " tobacco	1,344 to 2,016 lbs.
" " sugar	1,456 to 1,792 "
" " whisky	55 to 60 gals.
" " burgundy	44 "
" " claret	46 "
" " lisbon	58 "
" " port	57 "
" " sherry	54 "
Jar of olive oil	25 "
Last of salt	18 barrels
" potash, cod fish, herrings, meal, soap, tar	12 "
" flax or feathers	1,904 lbs.
" ale or beer	12 barrels
" gunpowder	24 "
Load of hay or straw	36 trusses
" bricks	500 number
" tiles	1,000 "
Pig of ballast	56 lbs.
Pipe of Cape wine	92 gals.
" Lisbon or Bucellas	117 "

MISCELLANEOUS WEIGHTS AND MEASURES (concluded).

Pipe of madeira	110 gals.
„ malaga	105 „
„ marsala	108 „
„ port	113 to 115 „
„ sherry or tent	92 to 108 „
„ teneriffe or vidonia	100 „
Pocket of hops	168 to 224 lbs.
Puncheon of brandy	110 to 120 gals.
„ „ rum	90 to 100 „
„ „ whisky (Scottish)	112 to 130 „
„ „ prunes	1,120 lbs.
„ „ molasses	1,120 to 1,344 „
Quintal of fish	112 „
Roll of parchment	60 skins
Sack of coals	224 lbs.
„ flour of 2 bolls	280 „
Tierce of beef (Irish) of 38 pieces	304 „
„ coffee	560 to 784 „
„ pork (Irish) of 80 pieces	320 „
Truss of straw	36 „
„ old hay	56 „
„ new hay	60 „
Tub of butter	84 „
Tun of oil (wine gals.)	252 gals.

MISCELLANEOUS NUMBERS.

12 units	make	1 dozen
13 units	„	1 long dozen
12 dozen	„	1 gross
12 gross, or 144 dozen	„	1 great gross
20 units	„	1 score
21 units	„	1 long score
5 score, or 100	„	1 short hundred
6 score, or 120	„	1 long hundred
24 sheets	„	1 quire of paper or parchment
20 sheets	„	1 quire of outside
25 sheets	„	1 printer's quire
20 quires, or 472 sheets	„	1 ream of ditto or parchment
21½ quires, or 516 sheets	„	1 perfect or printer's ream
2 reams	„	1 bundle of ditto
10 reams, or 200 quires	„	1 bale
5 doz., or 60 skins, of parchment	„	1 roll
4 pages, or 2 leaves	„	1 sheet of folio
8 pages, or 4 leaves	„	1 sheet of quarto or 4to.
16 pages, or 8 leaves	„	1 sheet of octavo or 8vo.
24 pages, or 12 leaves	„	1 sheet of duodecimo or 12mo.
36 pages, or 18 leaves	„	1 sheet of eighteens or 18mo.
72 words in common law	„	1 sheet
80 words in exchequer	„	1 sheet
90 words in chancery	„	1 sheet

Sizes and Contents of Casks.

Sundry Casks	Lgth. (ins.)	Diam. (ins.)	Contents (gals.)	Admiralty Casks	Lgth. (ins.)	Diam. (ins.)	Contents (gals.)
Marsala pipe .	65	32	108	Leager . .	59	38	164
„ hhd. .	41	25	45·5	Butt . .	53	33	110
Brandy pipe .	52	34	114	Puncheon .	41½	30	72
„ hhd. .	40	28	57·5	Hogshead .	37	28	54
Port pipe .	58	34	113	Barrel . .	31½	24·5	36
„ hhd. .	37	30	56·5	Half-hogshead	28	22·5	27
Sherry butt .	50	35	108	Kilderkin .	25	19·75	18
„ hhd. .	38	28	54·5	Firkin . .	22	17	12
Rum puncheon	42	36	91				

Size of Drawing Papers.

	Inches		Inches
Antiquarian . .	53 × 31	Royal . . .	24 × 19
Double elephant .	40 × 27	Medium . . .	22 × 17
Atlas	34 × 26	Demy . . .	20 × 15
Colombier . . .	34 × 23	Foolscap . . .	17 × 13½
Imperial . . .	30 × 22	Tracing papers . .	30 × 20
Elephant . . .	28 × 23	Ditto . . .	30 × 40
Super royal . .	27 × 19	Ditto . . .	60 × 40

Continuous tracing paper, 28, 31, 40, 44, and 56 in. wide by 21 yards long.
Continuous tracing linen, 18, 28, 36, 38, and 41 in. wide by 24 yards long.
Continuous drawing cartridge, 54, 57, 58, and 60 in. wide by 50 yards long.

METRICAL SYSTEM.

Long Measure (1).

	Metres	Inches	Feet	Yards	Miles
Millimetre .	= ·001	·03937	·00328	·00109	—
Centimetre .	·01	·39370	·03281	·01094	·000006
Decimetre .	·1	3·93704	·32809	·10936	·000062
Metre[1] . .	1	39·37043	3·28087	1·09362	·000621
Decametre .	10	393·7043	32·80869	10·93623	·006214
Hectometre .	100	3937·043	328·08693	109·36231	·062138
Kilometre .	1000	39370·43	3280·8693	1093·6231	·621377
Myriametre .	10000	393704·3	32808·693	10936·231	6·213768

Square Measure.

	Sq. Metres	Sq. Inches	Sq. Feet	Sq. Yards	Acres
Milliare .	= ·1	155	1·076	·119601	·0000247
Centiare .	1	1550	10·764	1·19601	·0002471
Deciare .	10	15500	107·641	11·9601	·0024711
Are[2] . .	100	155003	1076·410	119·601	·0247110
Decare . .	1000	1550031	10764·104	1196·01	·2471098
Hectare .	10000	15500309	107641·04	11960·12	2·4710981

[1] See Long Measure, next page. [2] The are=the square decametre.

Long Measure (2).

	Inches and Decimals of an In	Miles	Furls.	Poles	Yards	Feet	Inches and Fractions of an Inch
Millimetre .	= ·0394	......	......	......	......	......	......$\frac{1}{32}$...$\frac{1}{128}$ −
Centimetre	·3937	......	......	......	......	......	...$\frac{3}{8}$ ... $\frac{1}{64}$ ... −
Decimetre .	3·9370	......	......	......	......	......	3... $\frac{15}{16}$ ...... +
Metre .	39·3704	......	......	......	1	0	3 $\frac{5}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$ −
Decametre.	393·7043	......	......	1	5	1	3...$\frac{11}{16}$ ... $\frac{1}{64}$ +
Hectometre	3937·0432	......	......	19	4	2	7...$\frac{1}{32}$ $\frac{1}{64}$ ... −
Kilometre .	39370·4320	......	4	38	4	1	10 $\frac{3}{8}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$ +
Myriametre	393704·3196	6	1	28	2	0	8...$\frac{5}{16}$ ... $\frac{1}{128}$ −

Solid Measure.

	Cubic Metres	Cubic Inches	Cubic Feet	Cubic Yards
Millistere . .	= ·001	61·025	·03532	·00130
Centistere . .	·01	610·254	·35316	·01308
Decistere . .	·1	6102·539	3·53156	·13080
Stere[1] . . .	1	61025·387	35·31562	1·30799
Decastere . .	10	610253·866	353·15617	13·07986
Hectostere . .	100	6102538·659	3531·56172	130·79858

Weights.

	Grammes	Av. Oz.	Av. Lbs.	Cwts.	Tons	Grains Tr.
Milligramme .	= ·001	·00004	·0000022	—	—	·015432
Centigramme .	·01	·00035	·0000221	—	—	·154323
Decigramme .	·1	·00353	·0002205	·0000020	—	1·543235
Gramme[2]. .	1	·03527	·0022046	·0000197	·000001	15·43235
Decagramme .	10	·35274	·0220462	·0001968	·000010	154·3235
Hectogramme .	100	3·5274	·2204621	·0019684	·000098	1543·235
Kilogramme	1000	35·2739	2·204621	·0196841	·000984	15432·35
Myriagramme .	10000	352·739	22·04621	·1968412	·009842	154323·5
Quintal . .	100000	3527·39	220·4621	1·968412	·098421	1543235
Millier, or Tonne[3]	1000000	35273·9	2204·621	19·68412	·984206	15432349

Dry and Fluid Measure.

	Litres	Cubic Inches	Cubic Feet	Gallons	Bushels
Millilitre .	= ·001	·06102539	—	·00022	·00003
Centilitre .	·01	·61025387	·0004	·0022	·00028
Decilitre .	·1	6·1025387	·0035	·0220	·00275
Litre[4] . .	1	61·025387	·0353	·2201	·02751
Decalitre .	10	610·25387	·3532	2·2009	·27511
Hectolitre .	100	6102·5387	3·5316	22·0091	2·75113
Kilolitre .	1000	61025·387	35·3156	220·0905	27·51132
Myrialitre .	10000	610253·87	353·1562	2200·9055	275·11318

[1] The stere is a cubic metre, and is used generally for measuring solids.

[2] The gramme is the weight in vacuo of a cubic centimetre of distilled water at the temperature of 4° of the centigrade thermometer.

[3] Or tonneau in ship-building.

[4] The litre is a cubic decametre.

TABLES GIVING THE ENGLISH EQUIVALENTS OF 1 MILLIMETRE TO 1,000.

Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch
		39	1·535447	78	3·070894
1	0·039370	40	1·574817	79	3·110264
2	0·078741	41	1·614188	80	3·149635
3	0·118111	42	1·653558	81	3·189005
4	0·157482	43	1·692929	82	3·228375
5	0·196852	44	1·732299	83	3·267746
6	0·236223	45	1·771669	84	3·307116
7	0·275593	46	1·811040	85	3·346487
8	0·314963	47	1·850410	86	3·385857
9	0·354334	48	1·889781	87	3·425228
10	0·393704	49	1·929151	88	3·464598
11	0·433075	50	1·968522	89	3·503968
12	0·472445	51	2·007892	90	3·543339
13	0·511816	52	2·047262	91	3·582709
14	0·551186	53	2·086633	92	3·622080
15	0·590556	54	2·126003	93	3·661450
16	0·629927	55	2·165374	94	3·700821
17	0·669297	56	2·204744	95	3·740191
18	0·708668	57	2·244115	96	3·779561
19	0·748038	58	2·283485	97	3·818932
20	0·787409	59	2·322855	98	3·858302
21	0·826779	60	2·362226	99	3·897673
22	0·866149	61	2·401596	100	3·937043
23	0·905520	62	2·440967	101	3·976414
24	0·944890	63	2·480337	102	4·015784
25	0·984261	64	2·519708	103	4·055155
26	1·023631	65	2·559078	104	4·094525
27	1·063002	66	2·598448	105	4·133895
28	1·102372	67	2·637819	106	4·173266
29	1·141742	68	2·677189	107	4·212636
30	1·181113	69	2·716560	108	4·252007
31	1·220483	70	2·755930	109	4·291377
32	1·259854	71	2·795301	110	4·330748
33	1·299224	72	2·834671	111	4·370118
34	1·338595	73	2·874041	112	4·409488
35	1·377965	74	2·913412	113	4·448859
36	1·417335	75	2·952782	114	4·488229
37	1·456706	76	2·992153	115	4·527600
38	1·496076	77	3·031523	116	4·566970

Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch
117	4·606341	165	6·496121	213	8·385902
118	4·645711	166	6·535492	214	8·425272
119	4·685081	167	6·574862	215	8·464643
120	4·724452	168	6·614233	216	8·504013
121	4·763822	169	6·653603	217	8·543384
122	4·803193	170	6·692973	218	8·582754
123	4·842563	171	6·732344	219	8·622125
124	4·881934	172	6·771714	220	8·661495
125	4·921304	173	6·811085	221	8·700866
126	4·960674	174	6·850455	222	8·740236
127	5·000045	175	6·889826	223	8·779606
128	5·039415	176	6·929196	224	8·818977
129	5·078786	177	6·968567	225	8·858347
130	5·118156	178	7·007937	226	8·897718
131	5·157527	179	7·047307	227	8·937088
132	5·196897	180	7·086678	228	8·976459
133	5·236267	181	7·126048	229	9·015829
134	5·275638	182	7·165419	230	9·055199
135	5·315008	183	7·204789	231	9·094570
136	5·354379	184	7·244160	232	9·133940
137	5·393749	185	7·283530	233	9·173311
138	5·433120	186	7·322900	234	9·212681
139	5·472490	187	7·362271	235	9·252052
140	5·511861	188	7·401641	236	9·291422
141	5·551231	189	7·441012	237	9·330792
142	5·590601	190	7·480382	238	9·370163
143	5·629972	191	7·519753	239	9·409533
144	5·669342	192	7·559123	240	9·448904
145	5·708713	193	7·598493	241	9·488274
146	5·748083	194	7·637864	242	9·527645
147	5·787454	195	7·677234	243	9·567015
148	5·826824	196	7·716605	244	9·606385
149	5·866194	197	7·755975	245	9·645756
150	5·905565	198	7·795346	246	9·685126
151	5·944935	199	7·834716	247	9·724497
152	5·984306	200	7·874086	248	9·763867
153	6·023676	201	7·913457	249	9·803238
154	6·063047	202	7·952827	250	9·842608
155	6·102417	203	7·992198	251	9·881978
156	6·141787	204	8·031568	252	9·921349
157	6·181158	205	8·070939	253	9·960719
158	6·220528	206	8·110309	254	10·000090
159	6·259899	207	8·149679	255	10·039460
160	6·299269	208	8·189050	256	10·078831
161	6·338640	209	8·228420	257	10·118201
162	6·378010	210	8·267791	258	10·157571
163	6·417380	211	8·307161	259	10·196942
164	6·456751	212	8·346532	260	10·236312

Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch
261	10·275683	309	12·165464	357	14·055244
262	10·315053	310	12·204834	358	14·094615
263	10·354424	311	12·244204	359	14·133985
264	10·393794	312	12·283575	360	14·173356
265	10·433165	313	12·322945	361	14·212726
266	10·472535	314	12·362316	362	14·252096
267	10·511905	315	12·401686	363	14·291467
268	10·551276	316	12·441057	364	14·330837
269	10·590646	317	12·480427	365	14·370208
270	10·630017	318	12·519797	366	14·409578
271	10·669387	319	12·559168	367	14·448949
272	10·708758	320	12·598538	368	14·488319
273	10·748128	321	12·637909	369	14·527689
274	10·787498	322	12·677279	370	14·567060
275	10·826869	323	12·716650	371	14·606430
276	10·866239	324	12·756200	372	14·645801
277	10·905610	325	12·795390	373	14·685171
278	10·944980	326	12·834761	374	14·724542
279	10·984351	327	12·874131	375	14·763912
280	11·023721	328	12·913502	376	14·803282
281	11·063091	329	12·952872	377	14·842653
282	11·102462	330	12·992243	378	14·882023
283	11·141832	331	13·031613	379	14·921394
284	11·181203	332	13·070983	380	14·960764
285	11·220573	333	13·110354	381	15·000135
286	11·259944	334	13·149724	382	15·039505
287	11·299314	335	13·189095	383	15·078875
288	11·338684	336	13·228465	384	15·118246
289	11·378055	337	13·267836	385	15·157616
290	11·417425	338	13·307206	386	15·196987
291	11·456796	339	13·346576	387	15·236357
292	11·496166	340	13·385947	388	15·275728
293	11·535537	341	13·425317	389	15·315098
294	11·574907	342	13·464688	390	15·354469
295	11·614277	343	13·504058	391	15·393839
296	11·653648	344	13·543429	392	15·433209
297	11·693018	345	13·582799	393	15·472580
298	11·732389	346	13·622170	394	15·511950
299	11·771759	347	13·661540	395	15·551321
300	11·811130	348	13·700910	396	15·590691
301	11·850500	349	13·740281	397	15·630062
302	11·889871	350	13·779651	398	15·669432
303	11·929241	351	13·819022	399	15·708802
304	11·968611	352	13·858392	400	15·748173
305	12·007982	353	13·897763	401	15·787543
306	12·047352	354	13·937133	402	15·826914
307	12·086723	355	13·976503	403	15·866284
308	12·126093	356	14·015874	404	15·905655

Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch
405	15·945025	453	17·834806	501	19·724586
406	15·984395	454	17·874176	502	19·763957
407	16·023766	455	17·913547	503	19·803327
408	16·063136	456	17·952917	504	19·842698
409	16·102507	457	17·992287	505	19·882068
410	16·141877	458	18·031658	506	19·921439
411	16·181248	459	18·071028	507	19·960809
412	16·220618	460	18·110399	508	20·000179
413	16·259988	461	18·149769	509	20·039550
414	16·299359	462	18·189140	510	20·078920
415	16·338729	463	18·228510	511	20·118291
416	16·378100	464	18·267880	512	20·157661
417	16·417470	465	18·307251	513	20·197032
418	16·456841	466	18·346621	514	20·236402
419	16·496211	467	18·385992	515	20·275773
420	16·535581	468	18·425362	516	20·315143
421	16·574952	469	18·464733	517	20·354513
422	16·614322	470	18·504103	518	20·393884
423	16·653693	471	18·543474	519	20·433254
424	16·693063	472	18·582844	520	20·472625
425	16·732434	473	18·622214	521	20·511995
426	16·771804	474	18·661585	522	20·551366
427	16·811175	475	18·700955	523	20·590736
428	16·850545	476	18·740326	524	20·630106
429	16·889915	477	18·779696	525	20·669477
430	16·929286	478	18·819067	526	20·708847
431	16·968656	479	18·858437	527	20·748218
432	17·008027	480	18·897807	528	20·787588
433	17·047397	481	18·937178	529	20·826959
434	17·086768	482	18·976548	530	20·866329
435	17·126138	483	19·015919	531	20·905699
436	17·165508	484	19·055289	532	20·945070
437	17·204879	485	19·094660	533	20·984440
438	17·244249	486	19·134030	534	21·023811
439	17·283620	487	19·173400	535	21·063181
440	17·322990	488	19·212771	536	21·102552
441	17·362361	489	19·252141	537	21·141922
442	17·401731	490	19·291512	538	21·181292
443	17·441101	491	19·330882	539	21·220663
444	17·480472	492	19·370253	540	21·260033
445	17·519842	493	19·409623	541	21·299404
446	17·559213	494	19·448993	542	21·338774
447	17·598583	495	19·488364	543	21·378145
448	17·637954	496	19·527734	544	21·417515
449	17·677324	497	19·567095	545	21·456885
450	17·716694	498	19·606465	546	21·496256
451	17·756065	499	19·645836	547	21·535626
452	17·795435	500	19·685216	548	21·574997

Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch
549	21·614367	597	23·504148	645	25·393929
550	21·653738	598	23·543518	646	25·433299
551	21·693108	599	23·582889	647	25·472670
552	21·732478	600	23·622259	648	25·512040
553	21·771849	601	23·661630	649	25·551410
554	21·811219	602	23·701000	650	25·590781
555	21·850590	603	23·740371	651	25·630151
556	21·889960	604	23·779741	652	25·669522
557	21·929331	605	23·819111	653	25·708892
558	21·968701	606	23·858482	654	25·748263
559	22·008072	607	23·897852	655	25·787633
560	22·047442	608	23·937223	656	25·827003
561	22·086812	609	23·976593	657	25·866374
562	22·126183	610	24·015964	658	25·905744
563	22·165553	611	24·055334	659	25·945115
564	22·204924	612	24·094704	660	25·984486
565	22·244294	613	24·134075	661	26·023856
566	22·283665	614	24·173445	662	26·063226
567	22·323035	615	24·212816	663	26·102596
568	22·362405	616	24·252186	664	26·141967
569	22·401776	617	24·291557	665	26·181337
570	22·441146	618	24·330927	666	26·220708
571	22·480517	619	24·370297	667	26·260078
572	22·519887	620	24·409668	668	26·299449
573	22·559928	621	24·449038	669	26·338819
574	22·598628	622	24·488409	670	26·378189
575	22·637998	623	24·527779	671	26·417560
576	22·677369	624	24·567150	672	26·456930
577	22·716739	625	24·606520	673	26·496301
578	22·756110	626	24·645890	674	26·535671
579	22·795480	627	24·685261	675	26·575042
580	22·834851	628	24·724631	676	26·614412
581	22·874221	629	24·764002	677	26·653782
582	22·913591	630	24·803372	678	26·693153
583	22·952962	631	24·842743	679	26·732523
584	22·992332	632	24·882113	680	26·771894
585	23·031703	633	24·921483	681	26·811264
586	23·071073	634	24·960854	682	26·850635
587	23·110444	635	25·000224	683	26·890005
588	23·149814	636	25·039595	684	26·929376
589	23·189184	637	25·078965	685	26·968746
590	23·228555	638	25·118336	686	27·008116
591	23·267925	639	25·157706	687	27·047487
592	23·307296	640	25·197077	688	27·086857
593	23·346666	641	25·236447	689	27·126228
594	23·386037	642	25·275817	690	27·165598
595	23·425407	643	25·315188	691	27·204969
596	23·464778	644	25·354558	692	27·244339

Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch
693	27·283709	741	29·173490	789	31·063271
694	27·323080	742	29·212861	790	31·102641
695	27·362450	743	29·252231	791	31·142012
696	27·401821	744	29·291601	792	31·181382
697	27·441191	745	29·330972	793	31·220752
698	27·480562	746	29·370342	794	31·260123
699	27·519932	747	29·409713	795	31·299493
700	27·559302	748	29·449083	796	31·338864
701	27·598673	749	29·488454	797	31·378234
702	27·638043	750	29·527824	798	31·417604
703	27·677414	751	29·567194	799	31·456975
704	27·716784	752	29·606565	800	31·496346
705	27·756155	753	29·645935	801	31·535716
706	27·795525	754	29·685306	802	31·575086
707	27·834895	755	29·724676	803	31·614457
708	27·874266	756	29·764047	804	31·653827
709	27·913636	757	29·803417	805	31·693198
710	27·953007	758	29·842787	806	31·732568
711	27·992377	759	29·882158	807	31·771938
712	28·031748	760	29·921528	808	31·811309
713	28·071118	761	29·960899	809	31·850679
714	28·110488	762	30·000269	810	31·890050
715	28·149859	763	30·039640	811	31·929420
716	28·189229	764	30·079010	812	31·968791
717	28·228600	765	30·118380	813	32·008161
718	28·267970	766	30·157751	814	32·047532
719	28·307341	767	30·197121	815	32·086902
720	28·346711	768	30·236492	816	32·126272
721	28·386081	769	30·275862	817	32·165643
722	28·425452	770	30·315233	818	32·205013
723	28·464822	771	30·354603	819	32·244384
724	28·504193	772	30·393973	820	32·283754
725	28·543563	773	30·433344	821	32·323125
726	28·582934	774	30·472714	822	32·362495
727	28·622304	775	30·512085	823	32·401866
728	28·661675	776	30·551455	824	32·441236
729	28·701045	777	30·590825	825	32·480606
730	28·740415	778	30·630196	826	32·519977
731	28·779786	779	30·669566	827	32·559347
732	28·819156	780	30·708937	828	32·598718
733	28·858527	781	30·748307	829	32·638088
734	28·897897	782	30·787678	830	32·677459
735	28·937268	783	30·827048	831	32·716829
736	28·976638	784	30·866419	832	32·756199
737	29·016008	785	30·905789	833	32·795570
738	29·055379	786	30·945159	834	32·834940
739	29·094749	787	30·984530	835	32·874311
740	29·134120	788	31·023900	836	32·913681

Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch	Milli-metres	Inches and Decimals of an Inch
837	32·953052	885	34·842832	933	36·732613
838	32·992422	886	34·882203	934	36·771984
839	33·031792	887	34·921573	935	36·811354
840	33·071163	888	34·960944	936	36·850724
841	33·110533	889	35·000314	937	36·890095
842	33·149904	890	35·039684	938	36·929465
843	33·189274	891	35·079055	939	36·968836
844	33·228645	892	35·118425	940	37·008206
845	33·268015	893	35·157796	941	37·047576
846	33·307385	894	35·197166	942	37·086947
847	33·346756	895	35·236536	943	37·126317
848	33·386126	896	35·275907	944	37·165688
849	33·425497	897	35·315277	945	37·205058
850	33·464867	898	35·354648	946	37·244429
851	33·504238	899	35·394018	947	37·283799
852	33·543608	900	35·433389	948	37·323170
853	33·582979	901	35·472759	949	37·362540
854	33·622349	902	35·512130	950	37·410910
855	33·661719	903	35·551500	951	37·441281
856	33·701090	904	35·590971	952	37·480651
857	33·740460	905	35·630241	953	37·520022
858	33·779831	906	35·669611	954	37·559392
859	33·819201	907	35·708982	955	37·598765
860	33·858572	908	35·748352	956	37·638135
861	33·897942	909	35·787723	957	37·677503
862	33·937312	910	35·827093	958	37·716874
863	33·976683	911	35·866464	959	37·756244
864	34·016053	912	35·905834	960	37·795615
865	34·055424	913	35·945204	961	37·834985
866	34·094794	914	35·984575	962	37·874356
867	34·134165	915	36·023945	963	37·913726
868	34·173535	916	36·063316	964	37·953096
869	34·212905	917	36·102686	965	37·992467
870	34·252276	918	36·142057	966	38·031837
871	34·291646	919	36·181427	967	38·071208
872	34·331017	920	36·220797	968	38·110578
873	34·370387	921	36·260168	969	38·149949
874	34·409758	922	36·299538	970	38·189319
875	34·449128	923	36·338909	971	38·228689
876	34·448498	924	36·378279	972	38·268060
877	34·527869	925	36·417650	973	38·307430
878	34·567239	926	36·457020	974	38·346801
879	34·606610	927	36·496390	975	38·386171
880	34·645980	928	36·535761	976	38·425542
881	34·685351	929	36·575131	977	38·464912
882	34·724721	930	36·614502	978	38·504283
883	34·764091	931	36·653872	979	38·543653
884	34·803462	932	36·693243	980	38·583023

Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch	Millimetres	Inches and Decimals of an Inch
981	38·622394	988	38·897987	995	39·173580
982	38·661764	989	38·937357	996	39·212950
983	38·701135	990	38·976728	997	39·252321
984	38·740505	991	39·016098	998	39·291691
985	38·779876	992	39·055469	999	39·331062
986	38·819246	993	39·094839	1000	39·370432
987	38·858616	994	39·134209		

Table giving the English Equivalents of Metres in Inches and Decimals of an Inch.

Metres	Inches and Decimals of an Inch	Metres	Inches and Decimals of an Inch	Metres	Inches and Decimals of an Inch
1	39·370432	34	1338·594687	67	2637·818941
2	78·740864	35	1377·965119	68	2677·189373
3	118·111296	36	1417·335551	69	2716·559805
4	157·481728	37	1456·705983	70	2755·930237
5	196·852160	38	1496·076415	71	2795·300669
6	236·222592	39	1535·446846	72	2834·671101
7	275·593024	40	1574·817278	73	2874·041533
8	314·963456	41	1614·187710	74	2913·411965
9	354·333888	42	1653·558142	75	2952·782397
10	393·704320	43	1692·928574	76	2992·152829
11	433·074752	44	1732·299006	77	3031·523261
12	472·445184	45	1771·669438	78	3070·893693
13	511·815616	46	1811·039870	79	3110·264125
14	551·186047	47	1850·410302	80	3149·634557
15	590·556479	48	1889·780734	81	3189·004989
16	629·926911	49	1929·151166	82	3228·375421
17	669·297343	50	1968·521598	83	3267·745853
18	708·667775	51	2007·892030	84	3307·116285
19	748·038207	52	2047·262462	85	3346·486717
20	787·408639	53	2086·632894	86	3385·857149
21	826·779071	54	2126·003326	87	3425·227581
22	866·149503	55	2165·37358	88	3464·598013
23	905·519935	56	2204·744190	89	3503·968444
24	944·890367	57	2244·114622	90	3543·338876
25	984·260799	58	2283·485054	91	3582·709308
26	1023·631231	59	2322·855486	92	3622·079740
27	1063·001663	60	2362·225918	93	3661·450172
28	1102·372095	61	2401·596350	94	3700·820604
29	1141·742527	62	2440·966782	95	3740·191036
30	1181·112959	63	2480·337214	96	3779·561468
31	1220·483391	64	2519·707645	97	3818·931900
32	1259·853823	65	2559·078077	98	3858·302332
33	1299·224255	66	2598·448509	99	3897·672764

Table giving the Equivalents in Millimetres of the Divisions of the Inch.

Divisions of the Inch				Millimetres	Divisions of the Inch				Millimetres
...	...	...	1/128	·198436	5/16	...	1/64	1/128	8·532736
...	...	1/64	...	·396871	5/16	1/32	...	...	8·731172
...	...	1/64	1/128	·595307	5/16	1/32	...	1/128	8·929007
...	1/32	...	...	·793743	5/16	1/32	1/64	...	9·128043
...	1/32	...	1/128	·992179	5/16	1/32	1/64	1/128	9·326479
...	1/32	1/64	...	1·190614	3/8	...	...	...	9·524915
...	1/32	1/64	1/128	1·389050	3/8	...	...	1/128	9·723350
1/16	...	...	...	1·587486	3/8	...	1/64	...	9·921786
1/16	...	...	1/128	1·785921	3/8	...	1/64	1/128	10·120222
1/16	...	1/64	...	1·984357	3/8	1/32	...	...	10·318657
1/16	...	1/64	1/128	2·182793	3/8	1/32	...	1/128	10·517093
1/16	1/32	...	...	2·385129	3/8	1/32	1/64	...	10·715529
1/16	1/32	...	1/128	2·579664	3/8	1/32	1/64	1/128	10·913965
1/16	1/32	1/64	...	2·778100	7/16	...	...	...	11·112400
1/16	1/32	1/64	1/128	2·976536	7/16	...	...	1/128	11·310836
1/8	...	...	...	3·174972	7/16	...	1/64	...	11·509272
1/8	...	...	1/128	3·373407	7/16	...	1/64	1/128	11·707707
1/8	...	1/64	...	3·571843	7/16	1/32	...	...	11·906143
1/8	...	1/64	1/128	3·770279	7/16	1/32	...	1/128	12·104579
1/8	1/32	...	...	3·968714	7/16	1/32	1/64	...	12·303015
1/8	1/32	...	1/128	4·167150	7/16	1/32	1/64	1/128	12·501450
1/8	1/32	1/64	...	4·365586	1/2	...	...	...	12·699886
1/8	1/32	1/64	1/128	4·564022	1/2	...	...	1/128	12·898322
3/16	...	...	...	4·762457	1/2	...	1/64	...	13·096757
3/16	...	...	1/128	4·960893	1/2	...	1/64	1/128	13·295193
3/16	...	1/64	...	5·159329	1/2	1/32	...	...	13·493629
3/16	...	1/64	1/128	5·357764	1/2	1/32	...	1/128	13·692065
3/16	1/32	...	...	5·556200	1/2	1/32	1/64	...	13·890500
3/16	1/32	...	1/128	5·754636	1/2	1/32	1/64	1/128	14·088936
3/16	1/32	1/64	...	5·953072	9/16	...	...	...	14·287372
3/16	1/32	1/64	1/128	6·151508	9/16	...	...	1/128	14·485808
1/4	...	...	...	6·349943	9/16	...	1/64	...	14·684243
1/4	...	...	1/128	6·548379	9/16	...	1/64	1/128	14·882679
1/4	...	1/64	...	6·746814	9/16	1/32	...	...	15·081115
1/4	...	1/64	1/128	6·945250	9/16	1/32	...	1/128	15·279550
1/4	1/32	...	...	7·143686	9/16	1/32	1/64	...	15·477986
1/4	1/32	...	1/128	7·342122	9/16	1/32	1/64	1/128	15·676422
1/4	1/32	1/64	...	7·540557	5/8	...	...	...	15·874858
1/4	1/32	1/64	1/128	7·738993	5/8	...	...	1/128	16·073293
5/16	...	...	...	7·937429	5/8	...	1/64	...	16·271729
5/16	...	...	1/128	8·135865	5/8	...	1/64	1/128	16·470165
5/16	...	1/64	...	8·334300	5/8	1/32	...	...	16·668600

Divisions of the Inch	Millimetres	Divisions of the Inch	Millimetres
$\frac{5}{8}$ $\frac{1}{32}$ ... $\frac{1}{128}$	16·867036	$\frac{13}{16}$ ... $\frac{1}{64}$ $\frac{1}{128}$	21·232622
$\frac{5}{8}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	17·065472	$\frac{13}{16}$ $\frac{1}{32}$	21·431058
$\frac{5}{8}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	17·263908	$\frac{13}{16}$ $\frac{1}{32}$ ... $\frac{1}{128}$	21·629493
$\frac{11}{16}$	17·462343	$\frac{13}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	21·827929
$\frac{11}{16}$ ... ... $\frac{1}{128}$	17·660779	$\frac{13}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	22·026365
$\frac{11}{16}$ ... $\frac{1}{64}$ ...	17·859215	$\frac{7}{8}$	22·224801
$\frac{11}{16}$ ... $\frac{1}{64}$ $\frac{1}{128}$	18·057650	$\frac{7}{8}$ ... ... $\frac{1}{128}$	22·423236
$\frac{11}{16}$ $\frac{1}{32}$	18·256086	$\frac{7}{8}$ ... $\frac{1}{64}$ ...	22·621672
$\frac{11}{16}$ $\frac{1}{32}$ ... $\frac{1}{128}$	18·454522	$\frac{7}{8}$ ... $\frac{1}{64}$ $\frac{1}{128}$	22·820108
$\frac{11}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	18·652958	$\frac{7}{8}$ $\frac{1}{32}$	23·018543
$\frac{11}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	18·851393	$\frac{7}{8}$ $\frac{1}{32}$ ... $\frac{1}{128}$	23·216979
$\frac{3}{4}$	19·049829	$\frac{7}{8}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	23·415415
$\frac{3}{4}$ ... ... $\frac{1}{128}$	19·248265	$\frac{7}{8}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	23·613851
$\frac{3}{4}$ ... $\frac{1}{64}$ ...	19·446701	$\frac{15}{16}$	23·812286
$\frac{3}{4}$ ... $\frac{1}{64}$ $\frac{1}{128}$	19·645136	$\frac{15}{16}$ ... ... $\frac{1}{128}$	24·010722
$\frac{3}{4}$ $\frac{1}{32}$	19·843572	$\frac{15}{16}$ ... $\frac{1}{64}$ ...	24·209158
$\frac{3}{4}$ $\frac{1}{32}$ ... $\frac{1}{128}$	20·042008	$\frac{15}{16}$ ... $\frac{1}{64}$ $\frac{1}{128}$	24·407594
$\frac{3}{4}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	20·240443	$\frac{15}{16}$ $\frac{1}{32}$	24·606029
$\frac{3}{4}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	20·438879	$\frac{15}{16}$ $\frac{1}{32}$ ... $\frac{1}{128}$	24·804465
$\frac{13}{16}$	20·637315	$\frac{15}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ ...	25·002901
$\frac{13}{16}$ ... ... $\frac{1}{128}$	20·835751	$\frac{15}{16}$ $\frac{1}{32}$ $\frac{1}{64}$ $\frac{1}{128}$	25·201336
$\frac{13}{16}$ ... $\frac{1}{64}$ ...	21·034186	1	25·399772

TABLE GIVING THE EQUIVALENTS IN MILLIMETRES OF THE DIVISIONS OF THE FOOT.

In.	Millimetres	In.	Millimetres	In.	Millimetres	In.	Millimetres
1	25·39977	10	253·99772	19	482·59567	28	711·19362
2	50·79954	11	279·39749	20	507·99544	29	736·59339
3	76·19932	12	304·79727	21	533·39521	30	761·99316
4	101·59909	13	330·19704	22	558·79499	31	787·39294
5	126·99886	14	355·59681	23	584·19476	32	812·79271
6	152·39863	15	380·99658	24	609·59453	33	838·19248
7	177·79840	16	406·39635	25	634·99430	34	863·59225
8	203·19818	17	431·79613	26	660·39408	35	888·99202
9	228·59795	18	457·19590	27	685·78385	36	914·39180

TABLE GIVING THE EQUIVALENTS OF LINEAL FEET IN METRES.

Ft.	Metres	Ft.	Metres	Ft.	Metres	Ft.	Metres
1	·3047973	6	1·8287840	11	3·3527706	16	4·8767573
2	·6095947	7	2·1335813	12	3·6755680	17	5·1815546
3	·9143920	8	2·4383786	13	3·9623653	18	5·4863519
4	1·2191893	9	2·7431760	14	4·2671626	19	5·7911493
5	1·5239867	10	3·0479733	15	4·5719600	20	6·0959466

Table giving the Equivalents of Avoir. Oz. in French Kilograms.

Oz.	Kilograms	Oz.	Kilograms	Oz.	Kilograms	Oz.	Kilograms
1	·028349541	5	·141747704	9	·255145867	13	·368544030
2	·056699082	6	·170097245	10	·283495408	14	·396893571
3	·085048622	7	·198446785	11	·311844948	15	·425243112
4	·113398163	8	·226796326	12	·340194489	16	·453592652

Table giving the Equivalents of Avoir. Lbs. in French Kilograms.

Lbs.	Kilograms	Lbs.	Kilograms	Lbs.	Kilograms	Lbs.	Kilograms
1	·45359265	8	3·62874122	15	6·80388978	22	9·97908835
2	·90718530	9	4·08233387	16	7·25748243	23	10·43263100
3	1·36077796	10	4·53592652	17	7·71107509	24	10·88622365
4	1·81437061	11	4·98951917	18	8·16466774	25	11·33981631
5	2·26796326	12	5·44311183	19	8·61826039	26	11·79340896
6	2·72155591	13	5·89670448	20	9·07185305	27	12·24700161
7	3·17514857	14	6·35029713	21	9·52544570	28	12·70059426

Table giving the Equivalents of Quarters in French Kilograms.

Qr.	Kilograms	Qrs.	Kilograms	Qrs.	Kilograms	Qrs.	Kilograms
1	12·70059426	2	25·40118853	3	38·10178279	4	50·80237705

Table giving the Equivalents of Cwts. in French Kilograms.

Cwt	Kilograms	Cwt	Kilograms	Cwt	Kilograms	Cwt	Kilograms
1	50·80237705	6	304·81426231	11	558·82614757	16	812·83808283
2	101·60475410	7	355·61663936	12	609·62852462	17	863·64040988
3	152·40713116	8	406·41901642	13	660·43090168	18	914·44278694
4	203·20950821	9	457·22139347	14	711·23327873	19	965·24516399
5	254·01188526	10	508·02377052	15	762·03565578	20	1016·0475411

Table giving the Equivalents of Tons in French Kilograms.

Tons	Kilograms	Tons	Kilograms	Tons	Kilograms	Tons	Kilograms
1	1016·04754	20	20320·9508	300	304814·262	1300	1320861·80
2	2032·09508	30	30481·4262	400	406419·016	1400	1422466·56
3	3048·14262	40	40641·9016	500	508023·771	1500	1524071·31
4	4064·19016	50	50802·3771	600	609628·525	1600	1625676·07
5	5080·23771	60	60962·8525	700	711233·279	1700	1727280·82
6	6096·28525	70	71123·3279	800	812838·033	1800	1828885·57
7	7112·33279	80	81283·8033	900	914442·787	1900	1930490·33
8	8128·38033	90	91444·2787	1000	1016047·54	2000	2032095·08
9	9144·42787	100	101604·754	1100	1117652·30	3000	3048142·62
10	10160·4754	200	203209·508	1200	1219257·05	4000	4064190·16

TABLE GIVING THE EQUIVALENTS OF KILOGRAMS IN AVOIRDUPOIS POUNDS AND TONS.

Kilos.	Avoir. Lbs.	Ton	Kilos.	Avoir. Lbs.	Ton	Kilos.	Avoir. Lbs.	Ton	Kilos.	Avoir. Lbs.	Ton
1	2·20462	·00098421	26	57·32015	·02558935	51	112·43568	·05019450	76	167·55122	·07479965
2	4·40924	·00196841	27	59·52477	·02657356	52	114·64031	·05117871	77	169·75584	·07578386
3	6·61386	·00295262	28	61·72940	·02755777	53	116·84493	·05216291	78	171·96046	·07676806
4	8·81849	·00393682	29	63·93402	·02854197	54	119·04955	·05314712	79	174·16508	·07775227
5	11·02311	·00492103	30	66·13864	·02952618	55	121·25417	·05413133	80	176·36970	·07873647
6	13·22773	·00590524	31	68·34326	·03051038	56	123·45879	·05511553	81	178·57432	·07972068
7	15·43235	·00688944	32	70·54788	·03149459	57	125·66341	·05609974	82	180·77894	·08070489
8	17·63697	·00787365	33	72·75250	·03247880	58	127·86803	·05708394	83	182·98356	·08168909
9	19·84159	·00885785	34	74·95712	·03346300	59	130·07265	·05806815	84	185·18819	·08267330
10	22·04621	·00984206	35	77·16174	·03444721	60	132·27728	·05905235	85	187·39281	·08365750
11	24·25083	·01082627	36	79·36637	·03543141	61	134·48190	·06003656	86	189·59743	·08464171
12	26·45555	·01181047	37	81·57099	·03641562	62	136·68652	·06102077	87	191·80205	·08562591
13	28·66008	·01279468	38	83·77561	·03739982	63	138·89114	·06200497	88	194·00667	·08661012
14	30·86470	·01377888	39	85·98023	·03838403	64	141·09576	·06298918	89	196·21129	·08759433
15	33·06932	·01476309	40	88·18485	·03936824	65	143·30038	·06397338	90	198·41591	·08857853
16	35·27394	·01574729	41	90·38947	·04035244	66	145·50500	·06495759	91	200·62053	·08956274
17	37·47856	·01673150	42	92·59409	·04133665	67	147·70962	·06594180	92	202·82516	·09054694
18	39·68318	·01771571	43	94·79871	·04232085	68	149·91425	·06692600	93	205·02978	·09153115
19	41·88780	·01869991	44	97·00334	·04330506	69	152·11887	·06791021	94	207·23440	·09251536
20	44·09243	·01968412	45	99·20796	·04428927	70	154·32349	·06889441	95	209·43902	·09349956
21	46·29705	·02066832	46	101·41258	·04527347	71	156·52811	·06987862	96	211·64364	·09448377
22	48·50167	·02165253	47	103·61720	·04625768	72	158·73273	·07086283	97	213·84826	·09546797
23	50·70629	·02263674	48	105·82182	·04724188	73	160·93735	·07184703	98	216·05288	·09645218
24	52·91091	·02362094	49	108·02644	·04822609	74	163·14197	·07283124	99	218·25750	·09743639
25	55·11553	·02460515	50	110·23106	·04921030	75	165·34659	·07381544	100	220·46213	·09842059

Table of the Decimal Equivalents of Parts of a Ton.

Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton
1	·000446	370	·165179	820	·366071	1270	·566964
2	·000893	380	·169643	830	·370536	1280	·571429
3	·001339	390	·174107	840	·375000	1290	·575893
4	·001786	400	·178571	850	·379464	1300	·580357
5	·002232	410	·183036	860	·383929	1310	·584821
6	·002679	420	·187500	870	·388393	1320	·589286
7	·003125	430	·191964	880	·392857	1330	·593750
8	·003571	440	·196429	890	·397321	1340	·598214
9	·004018	450	·200893	900	·401786	1350	·602679
10	·004464	460	·205357	910	·406250	1360	·607143
20	·008929	470	·209821	920	·410714	1370	·611607
30	·013393	480	·214286	930	·415179	1380	·616071
40	·017851	490	·218750	940	·419643	1390	·620536
50	·022321	500	·223214	950	·424107	1400	·625000
60	·026786	510	·227679	960	·428571	1410	·629464
70	·031250	520	·232143	970	·433036	1420	·633929
80	·035714	530	·236607	980	·437500	1430	·638393
90	·040179	540	·241071	990	·441964	1440	·642857
100	·044643	550	·245536	1000	·446429	1450	·647321
110	·049107	560	·250000	1010	·450893	1460	·651786
120	·053571	570	·254464	1020	·455357	1470	·656250
130	·058036	580	·258929	1030	·459821	1480	·660714
140	·062500	590	·263393	1040	·464286	1490	·665179
150	·066964	600	·267857	1050	·468750	1500	·669643
160	·071429	610	·272321	1060	·473214	1510	·674107
170	·075893	620	·276786	1070	·477679	1520	·678571
180	·080357	630	·281250	1080	·482143	1530	·683036
190	·084821	640	·285714	1090	·486607	1540	·687500
200	·089286	650	·290179	1100	·491071	1550	·691964
210	·093750	660	·294643	1110	·495536	1560	·696429
220	·098214	670	·299107	1120	·500000	1570	·700893
230	·102679	680	·303571	1130	·504464	1580	·705357
240	·107143	690	·308036	1140	·508929	1590	·709821
250	·111607	700	·312500	1150	·513393	1600	·714286
260	·116071	710	·316964	1160	·517857	1610	·718750
270	·120536	720	·321429	1170	·522321	1620	·723214
280	·125000	730	·325893	1180	·526786	1630	·727679
290	·129464	740	·330357	1190	·531250	1640	·732143
300	·133929	750	·334821	1200	·535714	1650	·736607
310	·138393	760	·339286	1210	·540179	1660	·741071
320	·142857	770	·343750	1220	·544643	1670	·745536
330	·147321	780	·348214	1230	·549107	1680	·750000
340	·151786	790	·352679	1240	·553571	1690	·754464
350	·156250	800	·357143	1250	·558036	1700	·758929
360	·160714	810	·361607	1260	·562500	1710	·763393

Table of the Decimal Equivalents of Parts of a Ton (concluded).

Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton	Lbs.	Decimals of a Ton
1720	·767857	1850	·825893	1980	·883929	2110	·941964
1730	·772321	1860	·830357	1990	·888393	2120	·946429
1740	·776786	1870	·834821	2000	·892857	2130	·950893
1750	·781250	1880	·839286	2010	·897321	2140	·955357
1760	·785714	1890	·843750	2020	·901786	2150	·959821
1770	·790179	1900	·848214	2030	·906250	2160	·964286
1780	·794643	1910	·852679	2040	·910714	2170	·968750
1790	·799107	1920	·857143	2050	·915179	2180	·973214
1800	·803571	1930	·861607	2060	·919643	2190	·977679
1810	·808036	1940	·866071	2070	·924107	2200	·982143
1820	·812500	1950	·870536	2080	·928571	2210	·986607
1830	·816964	1960	·875000	2090	·933036	2220	·991071
1840	·821429	1970	·879464	2100	·937500	2230	·995536

2240 lbs. = 1 ton

Ozs.	Decimals of a Lb.	Ozs.	Decimals of a Lb.	Ozs.	Decimals of a Lb.	Ozs.	Decimals of a Lb.
¼	·015625	4¼	·265625	8¼	·515625	12¼	·765625
½	·031250	4½	·281250	8½	·531250	12½	·781250
¾	·046875	4¾	·296875	8¾	·546875	12¾	·796875
1	·062500	5	·312500	9	·562500	13	·812500
1¼	·078125	5¼	·328125	9¼	·578125	13¼	·828125
1½	·093750	5½	·343750	9½	·593750	13½	·843750
1¾	·109375	5¾	·359375	9¾	·609375	13¾	·859375
2	·125000	6	·375000	10	·625000	14	·875000
2¼	·140625	6¼	·390625	10¼	·640625	14¼	·890625
2½	·156250	6½	·406250	10½	·656250	14½	·906250
2¾	·171875	6¾	·421875	10¾	·671875	14¾	·921875
3	·187500	7	·437500	11	·687500	15	·937500
3¼	·203125	7¼	·453125	11¼	·703125	15¼	·953125
3½	·218750	7½	·468750	11½	·718750	15½	·968750
3¾	·234375	7¾	·484375	11¾	·734375	15¾	·984375
4	·250000	8	·500000	12	·750000	16	1·000000

Qr.	Decimals of a Ton	Qrs.	Decimals of a Ton	Qrs.	Decimals of a Ton	Qrs.	Decimals of a Ton
1	·012500	2	·025000	3	·037500	4	·050000

Cwts.	Decimals of a Ton	Cwts.	Decimals of a Ton	Cwts.	Decimals of a Ton	Cwts.	Decimals of a Ton	Cwts.	Decimals of a Ton
1	·050	5	·250	9	·450	13	·650	17	·850
2	·100	6	·300	10	·500	14	·700	18	·900
3	·150	7	·350	11	·550	15	·750	19	·950

Table of the Decimal Equivalents of the Divisions of the Foot.

In.	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	In.
0	·0000	·0052	·0104	·0156	·0208	·0260	·0313	·0365	·0417	·0469	·0521	·0573	·0625	·0677	·0729	·0781	0
1	·0833	·0885	·0937	·0990	·1042	·1094	·1146	·1198	·1250	·1302	·1354	·1406	·1458	·1510	·1563	·1615	1
2	·1667	·1719	·1771	·1823	·1875	·1927	·1979	·2031	·2083	·2135	·2188	·2240	·2292	·2344	·2396	·2448	2
3	·2500	·2552	·2604	·2656	·2708	·2760	·2813	·2865	·2917	·2969	·3021	·3073	·3125	·3177	·3229	·3281	3
4	·3333	·3385	·3437	·3490	·3542	·3594	·3646	·3698	·3750	·3802	·3854	·3906	·3958	·4010	·4063	·4115	4
5	·4167	·4219	·4271	·4323	·4375	·4427	·4479	·4531	·4583	·4635	·4688	·4740	·4792	·4844	·4896	·4948	5
6	·5000	·5052	·5104	·5156	·5208	·5260	·5313	·5365	·5417	·5469	·5521	·5573	·5625	·5677	·5729	·5781	6
7	·5833	·5885	·5937	·5990	·6042	·6094	·6146	·6198	·6250	·6302	·6354	·6406	·6458	·6510	·6563	·6615	7
8	·6667	·6719	·6771	·6823	·6875	·6927	·6979	·7031	·7083	·7135	·7187	·7240	·7292	·7344	·7396	·7448	8
9	·7500	·7552	·7604	·7656	·7708	·7760	·7813	·7865	·7917	·7969	·8021	·8073	·8125	·8177	·8229	·8281	9
10	·8333	·8385	·8437	·8490	·8542	·8594	·8646	·8698	·8750	·8802	·8854	·8906	·8958	·9010	·9063	·9115	10
11	·9167	·9219	·9271	·9323	·9375	·9427	·9479	·9531	·9583	·9635	·9688	·9740	·9792	·9844	·9896	·9948	11
In.	0	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	13/16	7/8	15/16	In.

Table of the Decimal Equivalents of the Divisions of the Yard.

Feet	0	1/12	1/6	3/12	1/3	5/12	1/2	7/12	2/3	9/12	5/6	11/12	Feet
0	·0000	·0278	·0556	·0833	·1111	·1389	·1667	·1944	·2222	·2500	·2778	·3056	0
1	·3333	·3611	·3889	·4167	·4444	·4722	·5000	·5278	·5556	·5833	·6111	·6389	1
2	·6667	·6944	·7222	·7500	·7778	·8056	·8333	·8611	·8889	·9167	·9444	·9722	2
Feet	0	1/12	1/6	3/12	1/3	5/12	1/2	7/12	2/3	9/12	5/6	11/12	Feet

Table of the Fractional Parts of the Inch, with their Corresponding Decimals.

Decimals	Fractions	Decimals	Fractions	Decimals	Fractions
		·3359375	5/16 ... 1/64 1/128	·6718750	5/8 1/32 1/64 ...
·0078125	... ... 1/128	·3437500	5/16 1/32	·6796875	5/8 1/32 1/64 1/128
·0156250	... ... 1/64 ...	·3515625	5/16 1/32 ... 1/128	·6875000	11/16 ... ...
·0234375	... ... 1/64 1/128	·3593750	5/16 1/32 1/64 ...	·6953125	11/16 ... ... 1/128
·0312500	... 1/32	·3671875	5/16 1/32 1/64 1/128	·7031250	11/16 ... 1/64 ...
·0390625	... 1/32 ... 1/128	·3750000	3/8	·7109375	11/16 ... 1/64 1/128
·0468750	... 1/32 1/64 ...	·3828125	3/8 ... ... 1/128	·7187500	11/16 1/32 ... ...
·0546875	... 1/32 1/64 1/128	·3906250	3/8 ... 1/64 ...	·7265625	11/16 1/32 ... 1/128
·0625000	1/16	·3984375	3/8 ... 1/64 1/128	·7343750	11/16 1/32 1/64 ...
·0703125	1/16 ... ... 1/128	·4062500	3/8 1/32	·7421875	11/16 1/32 1/64 1/128
·0781250	1/16 ... 1/64 ...	·4140625	3/8 1/32 ... 1/128	·7500000	3/4 ... ...
·0859375	1/16 ... 1/64 1/128	·4218750	3/8 1/32 1/64 ...	·7578125	3/4 ... ... 1/128
·0937500	1/16 1/32	·4296875	3/8 1/32 1/64 1/128	·7656250	3/4 ... 1/64 ...
·1015625	1/16 1/32 ... 1/128	·4375000	7/16	·7734375	3/4 ... 1/64 1/128
·1093750	1/16 1/32 1/64 ...	·4453125	7/16 ... ... 1/128	·7812500	3/4 1/32 ... ...
·1171875	1/16 1/32 1/64 1/128	·4531250	7/16 ... 1/64 ...	·7890625	3/4 1/32 ... 1/128
·1250000	1/8	·4609375	7/16 ... 1/64 1/128	·7968750	3/4 1/32 1/64 ...
·1328125	1/8 ... ... 1/128	·4687500	7/16 1/32	·8046875	3/4 1/32 1/64 1/128
·1406250	1/8 ... 1/64 ...	·4765625	7/16 1/32 ... 1/128	·8125000	13/16 ... ...
·1484375	1/8 ... 1/64 1/128	·4843750	7/16 1/32 1/64 ...	·8203125	13/16 ... ... 1/128
·1562500	1/8 1/32	·4921875	7/16 1/32 1/64 1/128	·8281250	13/16 ... 1/64 ...
·1640625	1/8 1/32 ... 1/128	·5000000	1/2	·8359375	13/16 ... 1/64 1/128
·1718750	1/8 1/32 1/64 ...	·5078125	1/2 ... ... 1/128	·8437500	13/16 1/32 ... ...
·1796875	1/8 1/32 1/64 1/128	·5156250	1/2 ... 1/64 ...	·8515625	13/16 1/32 ... 1/128
·1875000	3/16	·5234375	1/2 ... 1/64 1/128	·8593750	13/16 1/32 1/64 ...
·1953125	3/16 ... ... 1/128	·5312500	1/2 1/32	·8671875	13/16 1/32 1/64 1/128
·2031250	3/16 ... 1/64 ...	·5390625	1/2 1/32 ... 1/128	·8750000	7/8 ... ...
·2109375	3/16 ... 1/64 1/128	·5468750	1/2 1/32 1/64 ...	·8828125	7/8 ... ... 1/128
·2187500	3/16 1/32	·5546875	1/2 1/32 1/64 1/128	·8906250	7/8 ... 1/64 ...
·2265625	3/16 1/32 ... 1/128	·5625000	9/16	·8984375	7/8 ... 1/64 1/128
·2343750	3/16 1/32 1/64 ...	·5703125	9/16 ... ... 1/128	·9062500	7/8 1/32 ... ...
·2421875	3/16 1/32 1/64 1/128	·5781250	9/16 ... 1/64 ...	·9140625	7/8 1/32 ... 1/128
·2500000	1/4	·5859375	9/16 ... 1/64 1/128	·9218750	7/8 1/32 1/64 ...
·2578125	1/4 ... ... 1/128	·5937500	9/16 1/32	·9296875	7/8 1/32 1/64 1/128
·2656250	1/4 ... 1/64 ...	·6015625	9/16 1/32 ... 1/128	·9375000	15/16 ... ...
·2734375	1/4 ... 1/64 1/128	·6093750	9/16 1/32 1/64 ...	·9453125	15/16 ... ... 1/128
·2812500	1/4 1/32	·6171875	9/16 1/32 1/64 1/128	·9531250	15/16 ... 1/64 ...
·2890625	1/4 1/32 ... 1/128	·6250000	5/8	·9609375	15/16 ... 1/64 1/128
·2968750	1/4 1/32 1/64 ...	·6328125	5/8 ... ... 1/128	·9687500	15/16 1/32 ... ...
·3046875	1/4 1/32 1/64 1/128	·6406250	5/8 ... 1/64 ...	·9765625	15/16 1/32 ... 1/128
·3125000	5/16	·6484375	5/8 ... 1/64 1/128	·9843750	15/16 1/32 1/64 ...
·3203125	5/16 ... ... 1/128	·6562500	5/8 1/32	·9921875	15/16 1/32 1/64 1/128
·3281250	5/16 ... 1/64 ...	·6640625	5/8 1/32 ... 1/128	1·0000000	1 ... ...

Table of Foreign Money, Weights, and Measures, with their English Value.

Countries	MONEY					
	Gold Coins	Value	Silver Coins	Value	Silver Coins	Value
		£ s. d.		s. d.		s. d.
Austria	8 florins	15 10	2 florins	3 11½	½ florin	5¾
Bombay	Mohur	1 9 2	Rupee	1 10½	¼ rupee	5½
China	—	—	Tael	6 8	Mace	7
Denmark	20 krondaler	1 1 11½	4 krondaler	4 5½	Krondaler	1 1½
France[1]	20 francs	15 10	5 francs	3 11	Franc	9½
Germany	20 reichs-mark	1 0 0	5 reichs-mark	5 0	20 pfennige	2½
Greece	20 drachma	15 10	5 drachma	3 10	Drachma	9½
Holland	Ryder	1 5 1	Guilder	1 8	25 cents	5
Madras	Mohur	1 9 2	Rupee	1 10½	¼ rupee	5½
Portugal	5 milreas	1 3 4	500 reas	2 2	50 reas	2⅔
Russia	10 roubles	1 12 2½	Rouble	3 1½	25 copecs	9¼
Spain	20 pesetas	15 10	5 pesetas	3 11½	Peseta	9½
Sweden	20 krondaler	1 1 11½	4 krondaler	4 5½	Daler	8¾

Countries	LENGTH					
	Measure	Length	Measure	Length	Measure	Length
		Inches		Feet		Miles
Austria	Fuss	12·445	Klafter	6·2226	Meile	4·7142
Bombay	Hath	18	Guz	2·25	—	—
China	Chik	14·1	Yan	117·5	Li	·3458
Denmark	Fod	12·357	Aln	2·0595	Mil	4·6807
France	Mètre	39·3704	Décamètre	32·809	Myriamètre	6·2138
Germany	Fuss	12·357	Ruthe	12·357	Postmeile	4·6807
Greece	Attic foot	12·10	Stadium	600	—	—
Holland	Palm	3·93704	Elle	3·2809	Mijle	·6214
Madras	Covid	18·6	—	—	—	—
Portugal	Palmo	8·656	Vara	3·6067	Mil	1·2786
Russia	Archine	28	Sachine	7	Verst	·6629
Spain	Pie	11·128	Vara	2·782	Legua	4·2152
Sweden	Fot	11·6904	Famn	5·8452	Mil	6·6423

Countries	LIQUID CAPACITY					
	Measures	Gallons	Measures	Gallons	Measures	Gallons
Austria	Kanne	·1557	Viertel	3·1148	Eimer	12·4572
Bombay	Adoulie	1·515	Para	24·24	Candy	193·92
China	Shingtsong	·12	Tau	1·2	Hwüh	12
Denmark	Pott	·2126	Viertel	1·7008	Anker	8·2914
France	Litre	·2201	Décalitre	2·2009	Hectolitre	22·0097
Germany	Quartier	·252	Anker	7·559	Eimer	15·118
Greece	—	—	Metretes	8·488	—	—
Holland	Kan	·2201	—	—	Vat	22·0097
Madras	Puddy	·338	Marcal	2·704	Parah	13·52
Portugal	Canada	·3034	Pote	1·8202	Almüde	3·6405
Russia	Vedro	2·7049	Anker	8·1147	Sarokowaja	324·588
Spain	Quartillo	·1105	Azumbre	·4422	Arroba	3·5380
Sweden	Stop	·2878	Kanna	·5756	Tunna	27·6288

[1] France, Italy, Belgium, and Switzerland have perfect reciprocity in their currency.

TABLE OF FOREIGN MONEY, WEIGHTS, AND MEASURES, WITH THEIR ENGLISH VALUE (concluded).

Countries	DRY CAPACITY					
	Measure	Contents	Measure	Contents	Measure	Contents
		Bushels		Bushels		Quarters
Austria	Viertel	·4230	Metze	1·6918	Muth	6·3442
Bombay	Adoulie	·1893	Parah	3·08	Candy	3·3
China	Shingtsong	·02	Tau	·2	Hwŭh	·25
Denmark	Fjerding	·9567	Tonne	3·8268	Last	10·5235
France	Décalitre	·2751	Hectolitre	2·7511	Kilolitre	3·564
Germany	Viertel	·3780	Scheffel	1·5121	Wispel	3·4022
Greece	Bachel	·753	Kila	·9152	Staro	·2824
Holland	Schepel	·2751	Mudde	2·7511	Last	10·317
Madras	Puddy	·0423	Parah	1·69	Garce	16·9
Portugal	Alqueire	·372	Fanga	1·4878	Moio	2·79
Russia	Pajak	1·4426	Osmin	2·8852	Tschetwert	·7213
Spain	Almude	·1292	Fanega	1·5503	Cahiz	2·3254
Sweden	Kanna	·0720	Spann	2·015	Tunna	·50375

Countries	WEIGHT					
	Name	Weight	Name	Weight	Name	Weight
		Lbs.		Lbs.		Tons
Austria	Pfund	1·2352	Centner	12·352	—	—
Bombay	Seer	·7	Maund	28	Candy	·25
China	Tael	·0833	Catty	1·333	Pecul	·0595
Denmark	Mark	·5514	Pund	1·1029	Skippund	·1575
France	Kilogramme	2·2046	Quintal	220·46	Tonne	·9842
Germany	Pfund	1·0311	Centner	113·426	Schiffpfund	·1519
Greece	Pound	·8811	Oke	2·8	Cantaro	·05
Holland	Pond	2·2046	—	—	—	—
Madras	Seer	·625	Maund	25	Candy	·2232
Portugal	Arratel	1·0119	Arroba	32·3795	Quintal	·0578
Russia	Funt	·90264	Pud	36·1056	Packen	·4836
Spain	Marco	·5072	Libra	1·0144	Quintal	·0453
Sweden	Skälpund	·9376	Lispund	18·752	Skeppund	·1674

ENGLISH COINS.

POUND STERLING.

Pure gold in sovereign = 113·001 Troy grains.
Copper alloy in sovereign = 10·273 „
Fineness of sovereign = 22 carats = ·916⅔.
Total weight of sovereign = 123·273 Troy grains.

SILVER.

Weight of pure silver in half-crown = 201·8 Troy grains.
„ „ shilling = 80·7 „
„ „ sixpence = 40·3 „
Total weight of shilling = 87·273 „

A pound Avoirdupois of copper is coined in 24 pence or 48 halfpennies.

Table showing Rates of Discount at Various Percentages.

Amount Account	£5 per Cent.	£7½ per Cent.	£10 per Ct.	£12½ per Cent.	£15 per Cent.	£20 per Cent.	£25 per Cent.
£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
0 2 6	0 0 1½	0 0 2¼	0 0 3	0 0 3¾	0 0 4½	0 0 6	0 0 7½
0 5 0	0 0 3	0 0 4½	0 0 6	0 0 7½	0 0 9	0 1 0	0 1 3
0 10 0	0 0 6	0 0 9	0 1 0	0 1 3	0 1 6	0 2 0	0 2 6
0 15 0	0 0 9	0 1 1½	0 1 6	0 1 10½	0 2 3	0 3 0	0 3 9
1 0 0	0 1 0	0 1 6	0 2 0	0 2 6	0 3 0	0 4 0	0 5 0
1 10 0	0 1 6	0 2 3	0 3 0	0 3 9	0 4 6	0 6 0	0 7 6
1 15 0	0 1 9	0 2 7½	0 3 6	0 4 4½	0 5 3	0 7 0	0 8 9
2 0 0	0 2 0	0 3 0	0 4 0	0 5 0	0 6 0	0 8 0	0 10 0
2 10 0	0 2 6	0 3 9	0 5 0	0 6 3	0 7 6	0 10 0	0 12 6
2 15 0	0 2 9	0 4 1½	0 5 6	0 6 10½	0 8 3	0 11 0	0 13 9
3 0 0	0 3 0	0 4 6	0 6 0	0 7 6	0 9 0	0 12 0	0 15 0
3 10 0	0 3 6	0 5 3	0 7 0	0 8 9	0 10 6	0 14 0	0 17 6
3 15 0	0 3 9	0 5 7½	0 7 6	0 9 4½	0 11 3	0 15 0	0 18 9
4 0 0	0 4 0	0 6 0	0 8 0	0 10 0	0 12 0	0 16 0	1 0 0
4 10 0	0 4 6	0 6 9	0 9 0	0 11 3	0 13 6	0 18 0	1 2 6
4 15 0	0 4 9	0 7 1½	0 9 6	0 11 10½	0 14 3	0 19 0	1 3 9
5 0 0	0 5 0	0 7 6	0 10 0	0 12 6	0 15 0	1 0 0	1 5 0
5 10 0	0 5 6	0 8 3	0 11 0	0 13 9	0 16 6	1 2 0	1 7 6
5 15 0	0 5 9	0 8 7½	0 11 6	0 14 4½	0 17 3	1 3 0	1 8 9
6 0 0	0 6 0	0 9 0	0 12 0	0 15 0	0 18 0	1 4 0	1 10 0
6 10 0	0 6 6	0 9 9	0 13 0	0 16 3	0 19 6	1 6 0	1 12 6
6 15 0	0 6 9	0 10 1½	0 13 6	0 16 10½	1 0 3	1 7 0	1 13 9
7 0 0	0 7 0	0 10 6	0 14 0	0 17 6	1 1 0	1 8 0	1 15 0
7 10 0	0 7 6	0 11 3	0 15 0	0 18 9	1 2 6	1 10 0	1 17 6
8 0 0	0 8 0	0 12 0	0 16 0	1 0 0	1 4 0	1 12 0	2 0 0
8 10 0	0 8 6	0 12 9	0 17 0	1 1 3	1 5 6	1 14 0	2 2 6
9 0 0	0 9 0	0 13 6	0 18 0	1 2 6	1 7 0	1 16 0	2 5 0
9 10 0	0 9 6	0 14 3	0 19 0	1 3 9	1 8 6	1 18 0	2 7 6
10 0 0	0 10 0	0 15 0	1 0 0	1 5 0	1 10 0	2 0 0	2 10 0
10 10 0	0 10 6	0 15 9	1 1 0	1 6 3	1 11 6	2 2 0	2 12 6
11 0 0	0 11 0	0 16 6	1 2 0	1 7 6	1 13 0	2 4 0	2 15 0
11 10 0	0 11 6	0 17 3	1 3 0	1 8 9	1 14 6	2 6 0	2 17 6
12 0 0	0 12 0	0 18 0	1 4 0	1 10 0	1 16 0	2 8 0	3 0 0
12 10 0	0 12 6	0 18 9	1 5 0	1 11 3	1 17 6	2 10 0	3 2 6
13 0 0	0 13 0	0 19 6	1 6 0	1 12 6	1 19 0	2 12 0	3 5 0
13 10 0	0 13 6	1 0 3	1 7 0	1 13 9	2 0 6	2 14 0	3 7 6
14 0 0	0 14 0	1 1 0	1 8 0	1 15 0	2 2 0	2 16 0	3 10 0
14 10 0	0 14 6	1 1 9	1 9 0	1 16 3	2 3 6	2 18 0	3 12 6
15 0 0	0 15 0	1 2 6	1 10 0	1 17 6	2 5 0	3 0 0	3 15 0
20 0 0	1 0 0	1 10 0	2 0 0	2 10 0	3 0 0	4 0 0	5 0 0
30 0 0	1 10 0	2 5 0	3 0 0	3 15 0	4 10 0	6 0 0	7 10 0
40 0 0	2 0 0	3 0 0	4 0 0	5 0 0	6 0 0	8 0 0	10 0 0
50 0 0	2 10 0	3 15 0	5 0 0	6 5 0	7 10 0	10 0 0	12 10 0
60 0 0	3 0 0	4 10 0	6 0 0	7 10 0	9 0 0	12 0 0	15 0 0
70 0 0	3 10 0	5 5 0	7 0 0	8 15 0	10 10 0	14 0 0	17 10 0
80 0 0	4 0 0	6 0 0	8 0 0	10 0 0	12 0 0	16 0 0	20 0 0
90 0 0	4 10 0	6 15 0	9 0 0	11 5 0	13 10 0	18 0 0	22 10 0

Table showing the Equivalent Prices per Lb., Qr., Cwt., and Ton.

Per Lb.	Per Qr.		Per Cwt.		Per Ton			Per Lb.	Per Qr.		Per Cwt.		Per Ton			Per Lb.	Per Qr.		Per Cwt.		Per Ton			Per Lb.	Per Qr.		Per Cwt.		Per Ton		
d.	s.	d.	s.	d.	£	s.	d.	d.	s.	d.	s.	d.	£	s.	d.	d.	s.	d.	s.	d.	£	s.	d.	d.	s.	d.	s.	d.	£	s.	d.
⅛	0	3½	1	2	1	3	4	3⅛	7	3½	29	2	29	3	4	6⅛	14	3½	57	2	57	3	4	9⅛	21	3½	85	2	85	3	4
¼	0	7	2	4	2	6	8	3¼	7	7	30	4	30	6	8	6¼	14	7	58	4	58	6	8	9¼	21	7	86	4	86	6	8
⅜	0	10½	3	6	3	10	0	3⅜	7	10½	31	6	31	10	0	6⅜	14	10½	59	6	59	10	0	9⅜	21	10½	87	6	87	10	0
½	1	2	4	8	4	13	4	3½	8	2	32	8	32	13	4	6½	15	2	60	8	60	13	4	9½	22	2	88	8	88	13	4
⅝	1	5½	5	10	5	16	8	3⅝	8	5½	33	10	33	16	8	6⅝	15	5½	61	10	61	16	8	9⅝	22	5½	89	10	89	16	8
¾	1	9	7	0	7	0	0	3¾	8	9	35	0	35	0	0	6¾	15	9	63	0	63	0	0	9¾	22	9	91	0	91	0	0
⅞	2	0½	8	2	8	3	4	3⅞	9	0½	36	2	36	3	4	6⅞	16	0½	64	2	64	3	4	9⅞	23	0½	92	2	92	3	4
1	2	4	9	4	9	6	8	4	9	4	37	4	37	6	8	7	16	4	65	4	65	6	8	10	23	4	93	4	93	6	8
1⅛	2	7½	10	6	10	10	0	4⅛	9	7½	38	6	38	10	0	7⅛	16	7½	66	6	66	10	0	10⅛	23	7½	94	6	94	10	0
1¼	2	11	11	8	11	13	4	4¼	9	11	39	8	39	13	4	7¼	16	11	67	8	67	13	4	10¼	23	11	95	8	95	13	4
1⅜	3	2½	12	10	12	16	8	4⅜	10	2½	40	10	40	16	8	7⅜	17	2½	68	10	68	16	8	10⅜	24	2½	96	10	96	16	8
1½	3	6	14	0	14	0	0	4½	10	6	42	0	42	0	0	7½	17	6	70	0	70	0	0	10½	24	6	98	0	98	0	0
1⅝	3	9½	15	2	15	3	4	4⅝	10	9½	43	2	43	3	4	7⅝	17	9½	71	2	71	3	4	10⅝	24	9½	99	2	99	3	4
1¾	4	1	16	4	16	6	8	4¾	11	1	44	4	44	6	8	7¾	18	1	72	4	72	6	8	10¾	25	1	100	4	100	6	8
1⅞	4	4½	17	6	17	10	0	4⅞	11	4½	45	6	45	10	0	7⅞	18	4½	73	6	73	10	0	10⅞	25	4½	101	6	101	10	0
2	4	8	18	8	18	13	4	5	11	8	46	8	46	13	4	8	18	8	74	8	74	13	4	11	25	8	102	8	102	13	4
2⅛	4	11½	19	10	19	16	8	5⅛	11	11½	47	10	47	16	8	8⅛	18	11½	75	10	75	16	8	11⅛	25	11½	103	10	103	16	8
2¼	5	3	21	0	21	0	0	5¼	12	3	49	0	49	0	0	8¼	19	3	77	0	77	0	0	11¼	26	3	105	0	105	0	0
2⅜	5	6½	22	2	22	3	4	5⅜	12	6½	50	2	50	3	4	8⅜	19	6½	78	2	78	3	4	11⅜	26	6½	106	2	106	3	4
2½	5	10	23	4	23	6	8	5½	12	10	51	4	51	6	8	8½	19	10	79	4	79	6	8	11½	26	10	107	4	107	6	8
2⅝	6	1½	24	6	24	10	0	5⅝	13	1½	52	6	52	10	0	8⅝	20	1½	80	6	80	10	0	11⅝	27	1½	108	6	108	10	0
2¾	6	5	25	8	25	13	4	5¾	13	5	53	8	53	13	4	8¾	20	5	81	8	81	13	4	11¾	27	5	109	8	109	13	4
2⅞	6	8½	26	10	26	16	8	5⅞	13	8½	54	10	54	16	8	8⅞	20	8½	82	10	82	16	8	11⅞	27	8½	110	10	110	16	8
3	7	0	28	0	28	0	0	6	14	0	56	0	56	0	0	9	21	0	84	0	84	0	0	12	28	0	112	0	112	0	0

TABLE SHOWING AMOUNT EARNED IN ANY NUMBER OF HOURS FROM 1 TO 54, AT ALL RATES FROM 7s. TO 15s. FOR A WEEK OF 54 HOURS.

Rate of Wages in Shillings for a Week of 54 Hours — Amount Earned in given Number of Hours

No. of Hours at Work	7			8			9			10			11			12			13			14			15		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	0	1½	0	0	1¾	0	0	2	0	0	2¼	0	0	2½	0	0	2¾	0	0	3	0	0	3	0	0	3¼
2	0	0	3	0	0	3½	0	0	4	0	0	4½	0	0	5	0	0	5¼	0	0	5¾	0	0	6¼	0	0	6¾
3	0	0	4¾	0	0	5¼	0	0	6	0	0	6¾	0	0	7¼	0	0	8	0	0	8¾	0	0	9¼	0	0	10
4	0	0	6¼	0	0	7	0	0	8	0	0	9	0	0	9¾	0	0	10¾	0	0	11½	0	1	0½	0	1	1¼
5	0	0	7¾	0	0	9	0	0	10	0	0	11	0	1	0¼	0	1	1¼	0	1	2½	0	1	3½	0	1	4¾
6	0	0	9¼	0	0	10¾	0	1	0	0	1	1¼	0	1	2¾	0	1	4	0	1	5¼	0	1	6¾	0	1	8
7	0	0	11	0	1	0½	0	1	2	0	1	3½	0	1	5	0	1	6¾	0	1	8¼	0	1	9¾	0	1	11¼
8	0	1	0½	0	1	2¼	0	1	4	0	1	5¾	0	1	7½	0	1	9¼	0	1	11	0	2	1	0	2	2¾
9	0	1	2	0	1	4	0	1	6	0	1	8	0	1	10	0	2	0	0	2	2	0	2	4	0	2	6
10	0	1	3½	0	1	5¾	0	1	8	0	1	10¼	0	2	0½	0	2	2¾	0	2	5	0	2	7	0	2	9¼
11	0	1	5	0	1	7½	0	1	10	0	2	0½	0	2	3	0	2	5¼	0	2	7¾	0	2	10¼	0	3	0¾
12	0	1	6¾	0	1	9¼	0	2	0	0	2	2¾	0	2	5¼	0	2	8	0	2	10¾	0	3	1¼	0	3	4
13	0	1	8¼	0	1	11	0	2	2	0	2	5	0	2	7¾	0	2	10¾	0	3	1½	0	3	4½	0	3	7¼
14	0	1	9¾	0	2	1	0	2	4	0	2	7	0	2	10¼	0	3	1¼	0	3	4½	0	3	7½	0	3	10¾
15	0	1	11¼	0	2	2¾	0	2	6	0	2	9¼	0	3	0¾	0	3	4	0	3	7¼	0	3	10½	0	4	2
16	0	2	1	0	2	4½	0	2	8	0	2	11½	0	3	3	0	3	6¾	0	3	10¼	0	4	1¾	0	4	5¼
17	0	2	2½	0	2	6¼	0	2	10	0	3	1¾	0	3	5½	0	3	9¼	0	4	1	0	4	5	0	4	8¾
18	0	2	4	0	2	8	0	3	0	0	3	4	0	3	8	0	4	0	0	4	4	0	4	8	0	5	0
19	0	2	5½	0	2	9¾	0	3	2	0	3	6¼	0	3	10½	0	4	2¾	0	4	7	0	4	11	0	5	3¼
20	0	2	7	0	2	11½	0	3	4	0	3	8½	0	4	1	0	4	5¼	0	4	9¾	0	5	2¼	0	5	6¾
21	0	2	8¾	0	3	1¼	0	3	6	0	3	10¾	0	4	3¼	0	4	8	0	5	0¾	0	5	5¼	0	5	10
22	0	2	10¼	0	3	3	0	3	8	0	4	1	0	4	5¾	0	4	10¾	0	5	3½	0	5	8½	0	6	1¼
23	0	2	11¾	0	3	5	0	3	10	0	4	3	0	4	8¼	0	5	1¼	0	5	6½	0	5	11½	0	6	4¾
24	0	3	1¼	0	3	6¾	0	4	0	0	4	5¼	0	4	10¾	0	5	4	0	5	9¼	0	6	2¾	0	6	8
25	0	3	3	0	3	8½	0	4	2	0	4	7½	0	5	1	0	5	6¾	0	6	0¼	0	6	5¾	0	6	11¼
26	0	3	4½	0	3	10¼	0	4	4	0	4	9¾	0	5	3½	0	5	9¼	0	6	3	0	6	9	0	7	2¾
27	0	3	6	0	4	0	0	4	6	0	5	0	0	5	6	0	6	0	0	6	6	0	7	0	0	7	6
28	0	3	7½	0	4	1¾	0	4	8	0	5	2¼	0	5	8½	0	6	2¾	0	6	9	0	7	3	0	7	9¼
29	0	3	9	0	4	3½	0	4	10	0	5	4½	0	5	11	0	6	5¼	0	6	11¾	0	7	6¼	0	8	0¾
30	0	3	10¾	0	4	5¼	0	5	0	0	5	6¾	0	6	1¼	0	6	8	0	7	2¾	0	7	9¼	0	8	4
31	0	4	0¼	0	4	7	0	5	2	0	5	9	0	6	3¾	0	6	10¾	0	7	5½	0	8	0½	0	8	7¼
32	0	4	1¾	0	4	9	0	5	4	0	5	11	0	6	6¼	0	7	1¼	0	7	8½	0	8	3½	0	8	10¾
33	0	4	3¼	0	4	10¾	0	5	6	0	6	1¼	0	6	8¾	0	7	4	0	7	11¼	0	8	6¾	0	9	2
34	0	4	5	0	5	0½	0	5	8	0	6	3½	0	6	11	0	7	6¾	0	8	2¼	0	8	9¾	0	9	5¼
35	0	4	6½	0	5	2¼	0	5	10	0	6	5¾	0	7	1½	0	7	9¼	0	8	5	0	9	1	0	9	8¾
36	0	4	8	0	5	4	0	6	0	0	6	8	0	7	4	0	8	0	0	8	8	0	9	4	0	10	0
37	0	4	9½	0	5	5¾	0	6	2	0	6	10¼	0	7	6½	0	8	2¾	0	8	11	0	9	7	0	10	3¼
38	0	4	11	0	5	7½	0	6	4	0	7	0½	0	7	9	0	8	5¼	0	9	1¾	0	9	10¼	0	10	6¾
39	0	5	0¾	0	5	9¼	0	6	6	0	7	2¾	0	7	11¼	0	8	8	0	9	4¾	0	10	1¼	0	10	10
40	0	5	2¼	0	5	11	0	6	8	0	7	5	0	8	1¾	0	8	10¾	0	9	7½	0	10	4½	0	11	1¼
41	0	5	3¾	0	6	1	0	6	10	0	7	7	0	8	4¼	0	9	1¼	0	9	10½	0	10	7½	0	11	4¾
42	0	5	5¼	0	6	2¾	0	7	0	0	7	9¼	0	8	6¾	0	9	4	0	10	1¼	0	10	10¾	0	11	8
43	0	5	7	0	6	4½	0	7	2	0	7	11½	0	8	9	0	9	6¾	0	10	4¼	0	11	1¾	0	11	11¼
44	0	5	8½	0	6	6¼	0	7	4	0	8	1¾	0	8	11½	0	9	9¼	0	10	7	0	11	5	0	12	2¾
45	0	5	10	0	6	8	0	7	6	0	8	4	0	9	2	0	10	0	0	10	10	0	11	8	0	12	6
46	0	5	11½	0	6	9¾	0	7	8	0	8	6¼	0	9	4½	0	10	2¾	0	11	1	0	11	11	0	12	9¼
47	0	6	1	0	6	11½	0	7	10	0	8	8½	0	9	7	0	10	5¼	0	11	3¾	0	12	2¼	0	13	0¾
48	0	6	2¾	0	7	1¼	0	8	0	0	8	10¾	0	9	9¼	0	10	8	0	11	6¾	0	12	5¼	0	13	4
49	0	6	4¼	0	7	3	0	8	2	0	9	1	0	9	11¾	0	10	10¾	0	11	9½	0	12	8½	0	13	7¼
50	0	6	5¾	0	7	5	0	8	4	0	9	3	0	10	2¼	0	11	1¼	0	12	0½	0	12	11½	0	13	10¾
51	0	6	7¼	0	7	6¾	0	8	6	0	9	5¼	0	10	4¾	0	11	4	0	12	3¼	0	13	2¾	0	14	2
52	0	6	9	0	7	8½	0	8	8	0	9	7½	0	10	7	0	11	6¾	0	12	6	0	13	5¾	0	14	5¼
53	0	6	10½	0	7	10¼	0	8	10	0	9	9¾	0	10	9½	0	11	9¼	0	12	9	0	13	9	0	14	8¾
54	0	7	0	0	8	0	0	9	0	0	10	0	0	11	0	0	12	0	0	13	0	0	14	0	0	15	0

Table showing Amount Earned in any Number of Hours from 1 to 54, at all Rates from 16s. to 24s. for a Week of 54 Hours.

No. of Hours at Work	Rate of Wages in Shillings for a Week of 54 Hours																										
	16			17			18			19			20			21			22			23			24		
	Amount Earned in given Number of Hours																										
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	0	3½	0	0	3¾	0	0	4	0	0	4¼	0	0	4½	0	0	4¾	0	0	5	0	0	5	0	0	5¼
2	0	0	7	0	0	7½	0	0	8	0	0	8½	0	0	9	0	0	9¼	0	0	9¾	0	0	10¼	0	0	10¾
3	0	0	10¾	0	0	11¼	0	1	0	0	1	0¾	0	1	1¼	0	1	2	0	1	2¾	0	1	3¼	0	1	4
4	0	1	2¼	0	1	3	0	1	4	0	1	5	0	1	5¾	0	1	6¾	0	1	7½	0	1	8½	0	1	9¼
5	0	1	5¾	0	1	7	0	1	8	0	1	9	0	1	10¼	0	1	11¼	0	2	0½	0	2	1½	0	2	2¾
6	0	1	9¼	0	1	10¾	0	2	0	0	2	1¼	0	2	2¾	0	2	4	0	2	5¼	0	2	6¾	0	2	8
7	0	2	1	0	2	2½	0	2	4	0	2	5½	0	2	7	0	2	8¾	0	2	10¼	0	2	11¾	0	3	1¼
8	0	2	4½	0	2	6¼	0	2	8	0	2	9¾	0	2	11½	0	3	1¼	0	3	3	0	3	5	0	3	6¾
9	0	2	8	0	2	10	0	3	0	0	3	2	0	3	4	0	3	6	0	3	8	0	3	10	0	4	0
10	0	2	11½	0	3	1¾	0	3	4	0	3	6¼	0	3	8½	0	3	10¾	0	4	1	0	4	3	0	4	5¼
11	0	3	3	0	3	5½	0	3	8	0	3	10½	0	4	1	0	4	3¼	0	4	5¾	0	4	8¼	0	4	10¾
12	0	3	6¾	0	3	9¼	0	4	0	0	4	2¾	0	4	5¼	0	4	8	0	4	10¾	0	5	1¼	0	5	4
13	0	3	10¼	0	4	1	0	4	4	0	4	7	0	4	9¾	0	5	0¾	0	5	3½	0	5	6½	0	5	9¼
14	0	4	1¾	0	4	5	0	4	8	0	4	11	0	5	2¼	0	5	5¼	0	5	8½	0	5	11½	0	6	2¾
15	0	4	5¼	0	4	8¾	0	5	0	0	5	3¼	0	5	6¾	0	5	10	0	6	1¼	0	6	4¾	0	6	8
16	0	4	9	0	5	0½	0	5	4	0	5	7½	0	5	11	0	6	2¾	0	6	6¼	0	6	9¾	0	7	1¼
17	0	5	0½	0	5	4¼	0	5	8	0	5	11¾	0	6	3½	0	6	7¼	0	6	11	0	7	3	0	7	6¾
18	0	5	4	0	5	8	0	6	0	0	6	4	0	6	8	0	7	0	0	7	4	0	7	8	0	8	0
19	0	5	7½	0	5	11¾	0	6	4	0	6	8¼	0	7	0	0	7	4¾	0	7	9	0	8	1	0	8	5¼
20	0	5	11	0	6	3½	0	6	8	0	7	0½	0	7	5	0	7	9¼	0	8	1¾	0	8	6¼	0	8	10¾
21	0	6	2¾	0	6	7¼	0	7	0	0	7	4¾	0	7	9¼	0	8	2	0	8	6¾	0	8	11¼	0	9	4
22	0	6	6¼	0	6	11	0	7	4	0	7	9	0	8	1¾	0	8	6¾	0	8	11½	0	9	4½	0	9	9¼
23	0	6	9¾	0	7	3	0	7	8	0	8	1	0	8	6¼	0	8	11¼	0	9	4½	0	9	9½	0	10	2¾
24	0	7	1¼	0	7	6¾	0	8	0	0	8	5¼	0	8	10¾	0	9	4	0	9	9¼	0	10	2¾	0	10	8
25	0	7	5	0	7	10½	0	8	4	0	8	9½	0	9	3	0	9	8¾	0	10	2¼	0	10	7¾	0	11	1¼
26	0	7	8½	0	8	2¼	0	8	8	0	9	1¾	0	9	7½	0	10	1¼	0	10	7	0	11	1	0	11	6¾
27	0	8	0	0	8	6	0	9	0	0	9	6	0	10	0	0	10	6	0	11	0	0	11	6	0	12	0
28	0	8	3½	0	8	9¾	0	9	4	0	9	10¼	0	10	4½	0	10	10¾	0	11	5	0	11	11	0	12	5¼
29	0	8	7	0	9	1½	0	9	8	0	10	2½	0	10	9	0	11	3¼	0	11	9¾	0	12	4¼	0	12	10¾
30	0	8	10¾	0	9	5¼	0	10	0	0	10	6¾	0	11	1¼	0	11	8	0	12	2¾	0	12	9¼	0	13	4
31	0	9	2¼	0	9	9	0	10	4	0	10	11	0	11	5¾	0	12	0¾	0	12	7½	0	13	2½	0	13	9¼
32	0	9	5¾	0	10	1	0	10	8	0	11	3	0	11	10	0	12	5¼	0	13	0½	0	13	7½	0	14	2¾
33	0	9	9¼	0	10	4¾	0	11	0	0	11	7¼	0	12	2¾	0	12	10	0	13	5¼	0	14	0¾	0	14	8
34	0	10	1	0	10	8½	0	11	4	0	11	11½	0	12	7	0	13	2¾	0	13	10¼	0	14	5¾	0	15	1¼
35	0	10	4½	0	11	0¼	0	11	8	0	12	3¾	0	12	11½	0	13	7¼	0	14	3	0	14	11	0	15	6¾
36	0	10	8	0	11	4	0	12	0	0	12	8	0	13	4	0	14	0	0	14	8	0	15	4	0	16	0
37	0	10	11½	0	11	7¾	0	12	4	0	13	0¼	0	13	8½	0	14	4¾	0	15	1	0	15	9	0	16	5¼
38	0	11	3	0	11	11½	0	12	8	0	13	4½	0	14	1	0	14	9¼	0	15	5¾	0	16	2¼	0	16	10¾
39	0	11	6¾	0	12	3¼	0	13	0	0	13	8¾	0	14	5¼	0	15	2	0	15	10¾	0	16	7¼	0	17	4
40	0	11	10¼	0	12	7	0	13	4	0	14	1	0	14	9¾	0	15	6¾	0	16	3½	0	17	0½	0	17	9¼
41	0	12	1¾	0	12	11	0	13	8	0	14	5	0	15	2¼	0	15	11¼	0	16	8½	0	17	5½	0	18	2¾
42	0	12	5¼	0	13	2¾	0	14	0	0	14	9¼	0	15	6¾	0	16	4	0	17	1¼	0	17	10¾	0	18	8
43	0	12	9	0	13	6½	0	14	4	0	15	1½	0	15	11	0	16	8¾	0	17	6¼	0	18	3¾	0	19	1¼
44	0	13	0½	0	13	10¼	0	14	8	0	15	5¾	0	16	3½	0	17	1¼	0	17	11	0	18	9	0	19	6¾
45	0	13	4	0	14	2	0	15	0	0	15	10	0	16	8	0	17	6	0	18	4	0	19	2	1	0	0
46	0	13	7½	0	14	5¾	0	15	4	0	16	2¼	0	17	0½	0	17	10¾	0	18	9	0	19	7	1	0	5¼
47	0	13	11	0	14	9½	0	15	8	0	16	6½	0	17	5	0	18	3¼	0	19	1¾	1	0	0¼	1	0	10¾
48	0	14	2¾	0	15	1¼	0	16	0	0	16	10¾	0	17	9¼	0	18	8	0	19	6¾	1	0	5¼	1	1	4
49	0	14	6¼	0	15	5	0	16	4	0	17	3	0	18	1¾	0	19	0¾	0	19	11½	1	0	10½	1	1	9¼
50	0	14	9¾	0	15	9	0	16	8	0	17	7	0	18	6¼	0	19	5¼	1	0	4½	1	1	3½	1	2	2¾
51	0	15	1¼	0	16	0¾	0	17	0	0	17	11¼	0	18	10¾	0	19	10	1	0	9¼	1	1	8¾	1	2	8
52	0	15	5	0	16	4½	0	17	4	0	18	3½	0	19	3	1	0	2¾	1	1	2¼	1	2	1¾	1	3	1¼
53	0	15	8½	0	16	8¼	0	17	8	0	18	7¾	0	19	7½	1	0	7¼	1	1	7	1	2	7	1	3	6¾

Table showing Amount Earned in any Number of Hours from 1 to 54, at all Rates from 25s. to 33s. for a Week of 54 Hours.

Rate of Wages in Shillings for a Week of 54 Hours

Amount Earned in given Number of Hours

No. of Hours at Work	25			26			27			28			29			30			31			32			33		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	0	5½	0	0	5¾	0	0	6	0	0	6¼	0	0	6½	0	0	6¾	0	0	7	0	0	7	0	0	7¼
2	0	0	11	0	0	11½	0	1	0	0	1	0½	0	1	1	0	1	1¼	0	1	1¾	0	1	2¼	0	1	2¾
3	0	1	4¾	0	1	5¼	0	1	6	0	1	6¾	0	1	7¼	0	1	8	0	1	8¾	0	1	9¼	0	1	10
4	0	1	10¼	0	1	11	0	2	0	0	2	1	0	2	1¾	0	2	2¾	0	2	3½	0	2	4½	0	2	5¼
5	0	2	3¾	0	2	5	0	2	6	0	2	7	0	2	8¼	0	2	9¼	0	2	10½	0	2	11½	0	3	0¾
6	0	2	9¼	0	2	10¾	0	3	0	0	3	1¼	0	3	2¾	0	3	4	0	3	5¼	0	3	6¾	0	3	8
7	0	3	3	0	3	4½	0	3	6	0	3	7½	0	3	9	0	3	10¾	0	4	0¼	0	4	1¾	0	4	3¼
8	0	3	8½	0	3	10¼	0	4	0	0	4	1¾	0	4	3½	0	4	5¼	0	4	7	0	4	9	0	4	10¾
9	0	4	2	0	4	4	0	4	6	0	4	8	0	4	10	0	5	0	0	5	2	0	5	4	0	5	6
10	0	4	7½	0	4	9¾	0	5	0	0	5	2¼	0	5	4½	0	5	6¾	0	5	9	0	5	11	0	6	1¼
11	0	5	1	0	5	3½	0	5	6	0	5	8½	0	5	11	0	6	1¼	0	6	3¾	0	6	6¼	0	6	8¾
12	0	5	6¾	0	5	9¼	0	6	0	0	6	2¾	0	6	5¼	0	6	8	0	6	10¾	0	7	1¼	0	7	4
13	0	6	0¼	0	6	3	0	6	6	0	6	9	0	6	11¾	0	7	2¾	0	7	5½	0	7	8½	0	7	11¼
14	0	6	5¾	0	6	9	0	7	0	0	7	3	0	7	6¼	0	7	9¼	0	8	0½	0	8	3½	0	8	6¾
15	0	6	11¼	0	7	2¾	0	7	6	0	7	9¼	0	8	0¾	0	8	4	0	8	7¼	0	8	10¾	0	9	2
16	0	7	5	0	7	8½	0	8	0	0	8	3½	0	8	7	0	8	10¾	0	9	2¼	0	9	5¾	0	9	9¼
17	0	7	10½	0	8	2¼	0	8	6	0	8	9¾	0	9	1½	0	9	5¼	0	9	9	0	10	1	0	10	4¾
18	0	8	4	0	8	8	0	9	0	0	9	4	0	9	8	0	10	0	0	10	4	0	10	8	0	11	0
19	0	8	9½	0	9	1¾	0	9	6	0	9	10¼	0	10	2½	0	10	6¾	0	10	11	0	11	3	0	11	7¼
20	0	9	3	0	9	7½	0	10	0	0	10	4½	0	10	9	0	11	1¼	0	11	5¾	0	11	10¼	0	12	2¾
21	0	9	8¾	0	10	1¼	0	10	6	0	10	10¾	0	11	3¼	0	11	8	0	12	0¾	0	12	5¼	0	12	10
22	0	10	2¼	0	10	7	0	11	0	0	11	5	0	11	9¾	0	12	2¾	0	12	7½	0	13	0½	0	13	5¼
23	0	10	7¾	0	11	1	0	11	6	0	11	11	0	12	4¼	0	12	9¼	0	13	2½	0	13	7½	0	14	0¾
24	0	11	1¼	0	11	6¾	0	12	0	0	12	5¼	0	12	10¾	0	13	4	0	13	9¼	0	14	2¾	0	14	8
25	0	11	7	0	12	0½	0	12	6	0	12	11½	0	13	5	0	13	10¾	0	14	4¼	0	14	9¾	0	15	3¼
26	0	12	0½	0	12	6¼	0	13	0	0	13	5¾	0	13	11½	0	14	5¼	0	14	11	0	15	5	0	15	10¾
27	0	12	6	0	13	0	0	13	6	0	14	0	0	14	6	0	15	0	0	15	6	0	16	0	0	16	6
28	0	12	11½	0	13	5¾	0	14	0	0	14	6¼	0	15	0½	0	15	6¾	0	16	1	0	16	7	0	17	1¼
29	0	13	5	0	13	11½	0	14	6	0	15	0½	0	15	7	0	16	1¼	0	16	7¾	0	17	2¼	0	17	8¾
30	0	13	10¾	0	14	5¼	0	15	0	0	15	6¾	0	16	1¼	0	16	8	0	17	2¾	0	17	9¼	0	18	4
31	0	14	4¼	0	14	11	0	15	6	0	16	1	0	16	7¾	0	17	2¾	0	17	9½	0	18	4½	0	18	11¼
32	0	14	9¾	0	15	5	0	16	0	0	16	7	0	17	2¼	0	17	9¼	0	18	4½	0	18	11½	0	19	6¾
33	0	15	3¼	0	15	10¾	0	16	6	0	17	1¼	0	17	8¾	0	18	4	0	18	11¼	0	19	6¾	1	0	2
34	0	15	9	0	16	4½	0	17	0	0	17	7½	0	18	3	0	18	10¾	0	19	6¼	1	0	1¾	1	0	9¼
35	0	16	2½	0	16	10¼	0	17	6	0	18	1¾	0	18	9½	0	19	5¼	1	0	1	1	0	9	1	1	4¾
36	0	16	8	0	17	4	0	18	0	0	18	8	0	19	4	1	0	0	1	0	8	1	1	4	1	2	0
37	0	17	1½	0	17	9¾	0	18	6	0	19	2¼	0	19	10½	1	0	6¾	1	1	3	1	1	11	1	2	7¼
38	0	17	7	0	18	3½	0	19	0	0	19	8½	1	0	5	1	1	1¼	1	1	9¾	1	2	6¼	1	3	2¾
39	0	18	0¾	0	18	9¼	0	19	6	1	0	2¾	1	0	11¼	1	1	8	1	2	4¾	1	3	1¼	1	3	10
40	0	18	6¼	0	19	3	1	0	0	1	0	9	1	1	5¾	1	2	2¾	1	2	11½	1	3	8½	1	4	5¼
41	0	18	11¾	0	19	9	1	0	6	1	1	3	1	2	0¼	1	2	9¼	1	3	6½	1	4	3½	1	5	0¾
42	0	19	5¼	1	0	2¾	1	1	0	1	1	9¼	1	2	6¾	1	3	4	1	4	1¼	1	4	10¾	1	5	8
43	0	19	11	1	0	8½	1	1	6	1	2	3½	1	3	1	1	3	10¾	1	4	8¼	1	5	5¾	1	6	3¼
44	1	0	4½	1	1	2¼	1	2	0	1	2	9¾	1	3	7½	1	4	5¼	1	5	3	1	6	1	1	6	10¾
45	1	0	10	1	1	8	1	2	6	1	3	4	1	4	2	1	5	0	1	5	10	1	6	8	1	7	6
46	1	1	3½	1	2	1¾	1	3	0	1	3	10¼	1	4	8½	1	5	6¾	1	6	5	1	7	3	1	8	1¼
47	1	1	9	1	2	7½	1	3	6	1	4	4½	1	5	3	1	6	1¼	1	6	11¾	1	7	10¼	1	8	8¾
48	1	2	2¾	1	3	1¼	1	4	0	1	4	10¾	1	5	9¼	1	6	8	1	7	6¾	1	8	5¼	1	9	4
49	1	2	8¼	1	3	7	1	4	6	1	5	5	1	6	3¾	1	7	2¾	1	8	1½	1	9	0½	1	9	11¼
50	1	3	1¾	1	4	1	1	5	0	1	5	11	1	6	10¼	1	7	9¼	1	8	8½	1	9	7½	1	10	6¾
51	1	3	7¼	1	4	6¾	1	5	6	1	6	5¼	1	7	4¾	1	8	4	1	9	3¼	1	10	2¾	1	11	2
52	1	4	1	1	5	0½	1	6	0	1	6	11½	1	7	11	1	8	10¾	1	9	10¼	1	10	9¾	1	11	9¼
53	1	4	6½	1	5	6¼	1	6	6	1	7	5¾	1	8	5½	1	9	5¼	1	10	5	1	11	5	1	12	4¾
54	1	5	0	1	6	0	1	7	0	1	8	0	1	9	0	1	10	0	1	11	0	1	12	0	1	13	0

Table showing Amount Earned in any Number of Hours from 1 to 54, at all Rates from 34s. to 42s. for a Week of 54 Hours.

No. of Hours at Work	Rate of Wages in Shillings for a Week of 54 Hours																										
	34			35			36			37			38			39			40			41			42		
	Amount Earned in given Number of Hours																										
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1	0	0	7½	0	0	7¾	0	0	8	0	0	8¼	0	0	8½	0	0	8¾	0	0	9	0	0	9	0	0	9¼
2	0	1	3	0	1	3½	0	1	4	0	1	4½	0	1	5	0	1	5¼	0	1	5¾	0	1	6¼	0	1	6¾
3	0	1	10¾	0	1	11¼	0	2	0	0	2	0¾	0	2	1¼	0	2	2	0	2	2¾	0	2	3¼	0	2	4
4	0	2	6¼	0	2	7	0	2	8	0	2	9	0	2	9¾	0	2	10¾	0	2	11½	0	3	0½	0	3	1¼
5	0	3	1¾	0	3	3	0	3	4	0	3	5	0	3	6¼	0	3	7¼	0	3	8	0	3	9½	0	3	10¾
6	0	3	9¼	0	3	10¾	0	4	0	0	4	1¼	0	4	2¾	0	4	4	0	4	5¼	0	4	6¾	0	4	8
7	0	4	5	0	4	6½	0	4	8	0	4	9½	0	4	11	0	5	0¾	0	5	2¼	0	5	3¾	0	5	5¼
8	0	5	0½	0	5	2¼	0	5	4	0	5	5¾	0	5	7½	0	5	9¼	0	5	11	0	6	1	0	6	2¾
9	0	5	8	0	5	10	0	6	0	0	6	2	0	6	4	0	6	6	0	6	8	0	6	10	0	7	0
10	0	6	3½	0	6	5¾	0	6	8	0	6	10¼	0	7	0½	0	7	2¾	0	7	5	0	7	7	0	7	9¼
11	0	6	11	0	7	1½	0	7	4	0	7	6½	0	7	9	0	7	11¼	0	8	1¾	0	8	4¼	0	8	6¾
12	0	7	6¾	0	7	9¼	0	8	0	0	8	2¾	0	8	5¼	0	8	8	0	8	10¾	0	9	1¼	0	9	4
13	0	8	2¼	0	8	5	0	8	8	0	8	11	0	9	1¾	0	9	4¾	0	9	7½	0	9	10½	0	10	1¼
14	0	8	9¾	0	9	1	0	9	4	0	9	7	0	9	10¼	0	10	1¼	0	10	4½	0	10	7½	0	10	10¾
15	0	9	5¼	0	9	8¾	0	10	0	0	10	3¼	0	10	6¾	0	10	10	0	11	1¼	0	11	4¾	0	11	8
16	0	10	1	0	10	4½	0	10	8	0	10	11½	0	11	3	0	11	6¾	0	11	10¼	0	12	1¾	0	12	5¼
17	0	10	8½	0	11	0¼	0	11	4	0	11	7¾	0	11	11½	0	12	3¼	0	12	7	0	12	11	0	13	2¾
18	0	11	4	0	11	8	0	12	0	0	12	4	0	12	8	0	13	0	0	13	4	0	13	8	0	14	0
19	0	11	11½	0	12	3¾	0	12	8	0	13	0¼	0	13	4½	0	13	8¾	0	14	1	0	14	5	0	14	9¼
20	0	12	7	0	12	11½	0	13	4	0	13	8½	0	14	1	0	14	5¼	0	14	9¾	0	15	2¼	0	15	6¾
21	0	13	2¾	0	13	7¼	0	14	0	0	14	4¾	0	14	9¼	0	15	2	0	15	6¾	0	15	11¼	0	16	4
22	0	13	10¼	0	14	3	0	14	8	0	15	1	0	15	5¾	0	15	10¾	0	16	3½	0	16	8½	0	17	1¼
23	0	14	5¾	0	14	11	0	15	4	0	15	9	0	16	2¼	0	16	7¼	0	17	0½	0	17	5½	0	17	10¾
24	0	15	1¼	0	15	6¾	0	16	0	0	16	5¼	0	16	10¾	0	17	4	0	17	9¼	0	18	2¾	0	18	8
25	0	15	9	0	16	2½	0	16	8	0	17	1½	0	17	7	0	18	0¾	0	18	6¼	0	18	11¾	0	19	5¼
26	0	16	4½	0	16	10¼	0	17	4	0	17	9¾	0	18	3½	0	18	9¼	0	19	3	0	19	9	1	0	2¾
27	0	17	0	0	17	6	0	18	0	0	18	6	0	19	0	0	19	6	1	0	0	1	0	6	1	1	0
28	0	17	7½	0	18	1¾	0	18	8	0	19	2¼	0	19	8½	1	0	2¾	1	0	9	1	1	3	1	1	9¼
29	0	18	3	0	18	9½	0	19	4	0	19	10½	1	0	5	1	0	11¼	1	1	5¾	1	2	0¼	1	2	6¾
30	0	18	10¼	0	19	5¼	1	0	0	1	0	6¾	1	1	1¼	1	1	8	1	2	2¾	1	2	9¼	1	3	4
31	0	19	6¼	1	0	1	1	0	8	1	1	3	1	1	9¾	1	2	4¾	1	2	11½	1	3	6½	1	4	1¼
32	1	0	1¾	1	0	9	1	1	4	1	1	11	1	2	6¼	1	3	1¼	1	3	8	1	4	3½	1	4	10¾
33	1	0	9¼	1	1	4¾	1	2	0	1	2	7¼	1	3	2¾	1	3	10	1	4	5¼	1	5	0¾	1	5	8
34	1	1	5	1	2	0½	1	2	8	1	3	3½	1	3	11	1	4	6¾	1	5	2¼	1	5	9¾	1	6	5¼
35	1	2	0½	1	2	8¼	1	3	4	1	3	11¾	1	4	7½	1	5	3¼	1	5	11	1	6	7	1	7	2¾
36	1	2	8	1	3	4	1	4	0	1	4	8	1	5	4	1	6	0	1	6	8	1	7	4	1	8	0
37	1	3	3½	1	3	11¾	1	4	8	1	5	4¼	1	6	0½	1	6	8¾	1	7	5	1	8	1	1	8	9¼
38	1	3	11	1	4	7½	1	5	4	1	6	0½	1	6	9	1	7	5¼	1	8	1¾	1	8	10¼	1	9	6¾
39	1	4	6¾	1	5	3¼	1	6	0	1	6	8¾	1	7	5¼	1	8	2	1	8	10¾	1	9	7¼	1	10	4
40	1	5	2¼	1	5	11	1	6	8	1	7	5	1	8	1¾	1	8	10¾	1	9	7½	1	10	4½	1	11	1¼
41	1	5	9¾	1	6	7	1	7	4	1	8	1	1	8	10¼	1	9	7¼	1	10	4½	1	11	1½	1	11	10¾
42	1	6	5¼	1	7	2¾	1	8	0	1	8	9¼	1	9	6¾	1	10	4	1	11	1¼	1	11	10¾	1	12	8
43	1	7	1	1	7	10½	1	8	8	1	9	5½	1	10	3	1	11	0¾	1	11	10¼	1	12	7¾	1	13	5¼
44	1	7	8½	1	8	6¼	1	9	4	1	10	1¾	1	10	11½	1	11	9¼	1	12	7	1	13	5	1	14	2¾
45	1	8	4	1	9	2	1	10	0	1	10	10	1	11	8	1	12	6	1	13	4	1	14	2	1	15	0
46	1	8	11½	1	9	9¾	1	10	8	1	11	6¼	1	12	4½	1	13	2¾	1	14	1	1	14	11	1	15	9¼
47	1	9	7	1	10	5½	1	11	4	1	12	2½	1	13	1	1	13	11¼	1	14	9¾	1	15	8¼	1	16	6¾
48	1	10	2¾	1	11	1¼	1	12	0	1	12	10¾	1	13	9¼	1	14	8	1	15	6¾	1	16	5¼	1	17	4
49	1	10	10¼	1	11	9	1	12	8	1	13	7	1	14	5¾	1	15	4¾	1	16	3½	1	17	2½	1	18	1¼
50	1	11	5¾	1	12	5	1	13	4	1	14	3	1	15	2¼	1	16	1¼	1	17	0½	1	17	11½	1	18	10¾
51	1	12	1¼	1	13	0¾	1	14	0	1	14	11¼	1	15	10¾	1	16	10	1	17	9¼	1	18	8¾	1	19	8
52	1	12	9	1	13	8½	1	14	8	1	15	7½	1	16	7	1	17	6¾	1	18	6¼	1	19	5¾	2	0	5¼
53	1	13	4½	1	14	4¼	1	15	4	1	16	3¾	1	17	3½	1	18	3¼	1	19	3	2	0	3	2	1	2¾
54	1	14	0	1	15	0	1	16	0	1	17	0	1	18	0	1	19	0	2	0	0	2	1	0	2	2	0

Timber Loads.

One ton of Ebony	= 26–30 c. feet	One ton of Baltic Fir	= 50–58 c. feet
" " Oak	= 32–40 "	" " Elm	= 53–59 "
" " Mahogany	= 32–50 "	" " Pine	= 55–60 "
" " Ash	= 36–45 "	" " Deals	= 55–65 "
" " Beech	= 42–50 "	" " Lime-tree	= 56–59 "
" " Maple	= 46–49 "	" " Scotch Fir	= 60–66 "
" " Walnut	= 50–54 "		

Weight of Earth, Rocks, etc., per cubic yard.

Sand	about 30 cwt.	Sandstone	about 39 cwt
Gravel	" 30 "	Shale	" 40 "
Mud	" 25 "	Quartz	" 41 "
Marl	" 26 "	Granite	" 42 "
Clay	" 31 "	Trap	" 42 "
Chalk	" 36 "	Slate	" 43 "

Table of the Points of the Compass and their Angles with the Meridian.

North		Points	°	′	″	Points	South	
		0¼	2	48	45	0¼		
		0½	5	37	30	0½		
		0¾	8	26	15	0¾		
N. by E.	N. by W.	1	11	15	0	1	S. by E.	S. by W.
		1¼	14	3	45	1¼		
		1½	16	52	30	1½		
		1¾	19	41	15	1¾		
NNE.	NNW.	2	22	30	0	2	SSE.	SSW.
		2¼	25	18	45	2¼		
		2½	28	7	30	2½		
		2¾	30	56	15	2¾		
NE. by N.	NW. by N.	3	33	45	0	3	SE. by S.	SW. by S.
		3¼	36	33	45	3¼		
		3½	39	22	30	3½		
		3¾	42	11	15	3¾		
NE.	NW.	4	45	0	0	4	SE.	SW.
		4¼	47	48	45	4¼		
		4½	50	37	30	4½		
		4¾	53	26	15	4¾		
NE. by E.	NW. by W.	5	56	15	0	5	SE. by E.	SW. by W.
		5¼	59	3	45	5¼		
		5½	61	52	30	5½		
		5¾	64	41	15	5¾		
ENE.	WNW.	6	67	30	0	6	ESE.	WSW.
		6¼	70	18	45	6¼		
		6½	73	7	30	6½		
		6¾	75	56	15	6¾		
E. by N.	W. by N.	7	78	45	0	7	E. by S.	W. by S.
		7¼	81	33	45	7¼		
		7½	84	22	30	7½		
		7¾	87	11	15	7¾		
East	West	8	90	0	0	8	East	West

TABLE OF DISTANCES OF THE VISIBLE HORIZON IN NAUTICAL MILES, THE HEIGHT OF THE EYE BEING IN FEET.

Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance	Height	Distance
1	1·06	21	4·87	41	6·81	61	8·31	81	9·57	101	10·69
2	1·50	22	4·99	42	6·89	62	8·37	82	9·63	102	10·74
3	1·84	23	5·10	[illegible]	6·97	63	8·44	83	9·69	103	10·79
4	2·13	24	5·21	44	7·05	64	8·51	84	9·75	104	10·84
5	2·38	25	5·32	45	7·13	65	8·58	85	9·80	105	10·89
6	2·60	26	5·42	46	7·21	66	8·64	86	9·86	106	10·95
7	2·81	27	5·52	47	7·29	67	8·70	[illegible]	9·92	107	11·00
8	3·01	28	5·62	48	7·37	68	8·77	88	9·98	108	11·05
9	3·19	29	5·72	49	7·44	69	8·83	[illegible]	10·03	109	11·10
10	3·36	30	5·82	50	7·52	70	8·89	90	10·09	110	11·15
11	3·53	31	5·92	51	7·59	71	8·96	91	10·14	111	11·20
12	3·68	32	6·01	52	7·67	72	9·02	92	10·20	112	11·25
13	3·83	33	6·11	53	7·74	73	9·09	93	10·25	113	11·30
14	3·98	34	6·20	54	7·81	74	9·15	94	10·31	114	11·35
15	4·12	35	6·29	55	7·89	75	9·21	95	10·36	115	11·40
16	4·25	36	6·38	56	7·96	76	9·27	96	10·42	116	11·45
17	4·38	37	6·47	57	8·03	77	9·33	97	10·47	117	11·50
18	4·51	38	6·56	58	8·10	78	9·39	98	10·53	118	11·55
19	4·63	39	6·64	59	8·17	79	9·45	99	10·58	119	11·60
20	4·76	40	6·73	60	8·24	80	9·51	100	10·63	120	11·65

Table of Whitworth's Standard Taps and Dies.

No. of Threads per Inch	Old Sizes (ins.)	New Sizes of Taps (ins.)	No. of Threads per Inch	Old Sizes (ins.)	New Sizes of Taps (ins.)	No. of Threads per Inch	Old Sizes (ins.)	New Sizes of Taps (ins.)	No. of Threads per Inch	Old Sizes (ins.)	New Sizes of Taps (ins.)
48	—	·100	14	—	·475	7	1⅛	1·125	3½	3	3·000
40	⅛	·125	12	½	·500	7	1¼	1·250	3¼	3¼	3·250
32	—	·150	12	—	·525	6	1⅜	1·375	3¼	3½	3·500
24	—	·175	12	—	·550	6	1½	1·500	3	3¾	3·750
24	—	·200	12	—	·575	5	1⅝	1·625	3	4	4·000
24	—	·225	12	—	·600	5	1¾	1·750	2⅞	4¼	4·250
20	¼	·250	11	⅝	·625	4½	1⅞	1·875	2⅞	4½	4·500
20	—	·275	11	—	·650	4½	2	2·000	2¾	4¾	4·750
18	—	·300	11	—	·675	4½	2⅛	2·125	2¾	5	5·000
18	—	·325	11	—	·700	4	2¼	2·250	2⅝	5¼	5·250
18	—	·350	10	¾	·750	4	2⅜	2·375	2⅝	5½	5·500
16	⅜	·375	10	—	·800	4	2½	2·500	2½	5¾	5·750
16	—	·400	9	⅞	·875	4	2⅝	2·625	2½	6	6·000
14	—	·425	9	—	·900	3½	2¾	2·750	—	—	—
14	—	·450	8	1	1·000	3½	2⅞	2·875	—	—	—

Note.—The angle of thread = 55°. Depth of thread = ⅔ of pitch bore—that is, deducting ⅙ for the quantity rounded off top and ⅙ off bottom.

Table of Whitworth's Standard Hexagonal Nut and Bolt-heads.

Diameter of Bolt	Distance across Flats	Thickness of Nut	Thickness of Bolt-head	Diam. at Bottom of Thread	Diameter of Bolt	Distance across Flats	Thickness of Nut	Thickness of Bolt-head	Diam. at Bottom of Thread
Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.	Ins.
⅛	·338	⅛	·1093	·0929	1¼	2·0483	1¼	1·0937	1·0670
3/16	·448	3/16	·1640	·1341	1⅜	2·2146	1⅜	1·2031	1·1615
¼	·525	¼	·2187	·1859	1½	2·4134	1½	1·3125	1·2865
5/16	·6014	5/16	·2734	·2413	1⅝	2·5763	1⅝	1·4218	1·3688
⅜	·7094	⅜	·3281	·2949	1¾	2·7578	1¾	1·5312	1·4938
7/16	·8204	7/16	·3828	·3460	1⅞	3·0183	1⅞	1·6406	1·5904
½	·9191	½	·4375	·3932	2	3·1491	2	1·7500	1·7154
9/16	1·0110	9/16	·4921	·4557	2⅛	3·3370	2⅛	1·8593	1·8404
⅝	1·1010	⅝	·5468	·5085	2¼	3·5460	2¼	1·9687	1·9298
11/16	1·2011	11/16	·6015	·5710	2⅜	3·7500	2⅜	2·0781	2·0548
¾	1·3012	¾	·6562	·6219	2½	3·8940	2½	2·1875	2·1798
13/16	1·3900	13/16	·7109	·6844	2⅝	4·0490	2⅝	2·2968	2·3048
⅞	1·4788	⅞	·7656	·7327	2¾	4·1810	2¾	2·4062	2·3840
15/16	1·5745	15/16	·8203	·7952	2⅞	4·3456	2⅞	2·5156	2·5090
1	1·6707	1	·8750	·8399	3	4·5310	3	2·6250	2·6340
1⅛	1·8605	1⅛	·9843	·9420	—	—	—	—	—

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE.

CIRCLE.	1	2	3	4	5	6	7	8	9
π	3·1416	6·2832	9·4248	12·5664	15·7080	18·8496	21·9912	25·1328	28·2744
$\pi \div 4$	·7854	1·5708	2·3562	3·1416	3·9270	4·7124	5·4978	6·2832	7·0686
$\pi \div 6$	·5236	1·0472	1·5708	2·0944	2·6180	3·1416	3·6652	4·1888	4·7124
$\pi \div 180$	·01745	·03490	·05236	·06980	·08725	·10470	·12215	·13960	·15705
$\pi \div 200$	·015708	·031416	·047124	·062832	·078540	·094248	·109956	·125664	·141372
$\pi\sqrt{2}$	4·44288	8·88576	13·32864	17·77152	22·21440	26·65728	31·10016	35·54304	39·98592
$\pi\sqrt{1 \div 2}$	2·22144	4·44288	6·66432	8·88576	11·10720	13·32864	15·55008	17·77152	19·99296
$\sqrt{\pi}$	1·772454	3·544908	5·317362	7·089816	8·862270	10·634724	12·407178	14·179632	15·952086
$\sqrt{\pi \div 4}$	·886227	1·772454	2·658681	3·544908	4·431135	5·317362	6·203589	7·089816	7·976043
$\sqrt{1 \div \pi}$	·5642	1·1284	1·6926	2·2568	2·8210	3·3852	3·9494	4·5136	5·0778
$\sqrt{1 \div 2}$	·707107	1·414214	2·121321	2·828428	3·534435	4·242642	4·949749	5·656856	6·363963
$\sqrt{2}$	1·41422	2·82844	4·24266	5·65688	7·07110	8·48532	9·89954	11·31376	12·72798
$\sqrt[3]{6 \div \pi}$	1·240701	2·481402	3·722103	4·962804	6·203505	7·444206	8·684907	9·925608	11·166309
$\sqrt[3]{\pi \div 6}$	·805996	1·611992	2·417988	3·223984	4·029980	4·835976	5·641972	6·447968	7·253964
$\sqrt[3]{36\pi}$	4·83598	9·67196	14·50794	19·34392	24·17990	29·01588	33·85186	38·68784	43·52382
$2\sqrt{\pi}$	3·54491	7·08982	10·63473	14·17964	17·72455	21·26946	24·81437	28·35928	31·90419
$2\sqrt{1 \div \pi}$	1·12838	2·25676	3·38514	4·51352	5·64190	6·77028	7·89866	9·02704	10·15542
$1 \div \pi$	·31831	·63662	·95493	1·27324	1·59155	1·90986	2·22817	2·54648	2·86479
$1 \div \sqrt{3}$	·5773502	1·1547004	1·7320506	2·3094008	2·8867510	3·4641012	4·0414514	4·6188016	5·1961518
$180 \div \pi$	57·29578	114·59156	171·88734	229·18312	296·47890	343·77468	401·07046	458·36624	515·66202
$200 \div \pi$	63·662	127·324	190·986	254·648	318·310	381·972	445·634	509·296	572·958
2π	6·2832	12·5664	18·8496	25·1328	31·4160	37·6992	43·9824	50·2656	56·5488
4π	12·5664	25·1328	37·6992	50·2656	62·8320	75·3984	87·9648	100·5312	113·0976
36π	113·0973	226·1946	339·2919	452·3892	565·4865	678·5838	791·6811	904·7784	1017·8757
$4\pi \div 3$	4·18879	8·37758	12·56637	16·75516	20·94395	25·13274	29·32153	33·51032	37·69911

Note.—For the more exact value and the significations of the constants in this table see 'Properties of the Circle.'

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

	1	2	3	4	5	6	7	8	9
Gravity.									
g	32·2	64·4	96·6	128·8	161·0	193·2	225·4	257·6	289·8
$g \div 2$	16·1	32·2	48·3	64·4	80·5	96·6	112·7	128·8	144·9
$g \div 4$	8·05	16·10	24·15	32·20	40·25	48·30	56·35	64·40	72·45
$1 \div g$	·03106	·06212	·09318	·12424	·15530	·18636	·21742	·24848	·27954
$1 \div 2g$	·01553	·03106	·04659	·06212	·07765	·09318	·10871	·12424	·13977
$2g$	64·4	128·8	193·2	257·6	322·0	386·4	450·8	515·2	579·6
$\sqrt{2g}$	8·025	16·050	24·075	32·100	40·125	48·150	56·175	64·200	72·225
Length.									
Miles = Austrian meiles ×	4·7142	9·4284	14·1426	18·8568	23·5710	28·2852	32·9994	37·7136	42·4278
Austrian meiles = miles ×	·21212	·42424	·63636	·84848	1·06060	1·27272	1·48484	1·69696	1·9098
Miles = French kilomètres ×	·62138	1·24276	1·86414	2·48552	3·10690	3·72828	4·34966	4·97104	5·59242
French kilomètres = miles ×	1·6093	3·2186	4·8279	6·4372	8·0465	9·6558	11·2651	12·8744	14·4837
Miles = German meiles ×	4·6807	9·3614	14·0421	18·7228	23·4035	28·0842	32·7649	37·4456	42·1263
German meiles = miles ×	·21364	·42728	·64092	·85456	1·06820	1·28184	1·49548	1·70912	1·92276
Miles = Russian versts ×	·66288	1·32576	1·98864	2·65152	3·31440	3·97728	4·64016	5·3034	5·96592
Russian versts = miles ×	1·5086	3·0172	4·5258	6·0344	7·5430	9·0516	10·5602	12·0688	13·5774
Miles = Swedish mils ×	6·6420	13·2840	19·9260	26·5680	33·2100	39·8520	46·4940	53·1360	59·7780
Swedish mils = miles ×	·15056	·30112	·45168	·60224	·75280	·90336	1·05392	1·20448	1·35504
Miles = Admiralty knots ×	1·1515	2·3030	3·4545	4·6060	5·7575	6·9090	8·0605	9·2120	10·3635
Admiralty knots = miles ×	·86842	1·73684	2·60526	3·47368	4·34210	5·21052	6·07894	6·94736	7·81578
Miles = nautical miles ×	1·1527	2·30547	3·4581	4·6108	5·7635	6·9162	8·0689	9·2216	10·3748
Nautical miles = miles ×	·86758	1·73506	2·60259	3·47012	4·33765	5·20518	6·07271	6·94024	7·80777
Miles = yards ×	·00057	·00114	·00171	·00228	·00285	·00342	·00399	·00456	·00513
Yards = miles ×	1760·0	3520·0	5280·0	7040·0	8800·0	10560·0	12320·0	14080·0	15840·0
Miles = feet ×	·00019	·00038	·00057	·00076	·00095	·00114	·00133	·00152	·00171
Feet = miles ×	5280·0	10560·0	15840·0	21120·0	26400·0	31680·0	36960·0	42240·0	47520·0

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

Length (concluded).		1	2	3	4	5	6	7	8	9
Feet = Austrian fuss .	×	1·0371	2·0742	3·1113	4·1484	5·1855	6·2226	7·2597	8·2968	9·3339
Austrian fuss = feet .	×	·96424	1·89248	2·83872	3·78496	4·73120	5·67744	6·62368	7·56992	8·51616
Feet = French mètres .	×	3·2809	6·5618	9·8427	13·1236	16·4045	19·6854	22·9663	26·2472	29·5281
French mètres = feet .	×	·30480	·60960	·91440	1·21920	1·52400	1·82880	2·13360	2·43840	2·74320
Feet = German fuss .	×	1·0298	2·0596	3·0894	4·1192	5·1490	6·1788	7·2086	8·2384	9·2682
German fuss = feet .	×	·97111	1·94222	2·91333	3·88444	4·85555	5·82666	6·79777	7·76888	8·73999
Feet = Swedish fots .	×	·97420	1·94840	2·92260	3·89680	4·87100	5·84520	6·81940	7·79360	8·76780
Swedish fots = feet. .	×	1·0265	2·0530	3·0795	4·1060	5·1325	6·1590	7·1855	8·2120	9·2385
Square Measure.										
Acres = sq. miles . .	×	640	1280	1920	2560	3200	3840	4480	5120	5760
Sq. miles = acres . .	×	·0015625	·0031250	·0046875	·0062500	·0078125	·0093750	·0109375	·0125000	·0140625
Acres = French ares .	×	·0247111	·0494222	·0741333	·0988444	·1235555	·1482666	·1729777	·1976888	·2223999
French ares = acres .	×	40·46782	80·93564	121·40346	161·87128	202·33910	242·80692	283·27474	323·74256	364·21048
Acres = sq. yards . .	×	·00020661	·00041322	·00061983	·00082644	·00103305	·00123966	·00144627	·00165288	·00185949
Sq. yards = acres . .	×	4840	9680	14520	19360	24200	29040	33880	38720	43560
Sq. miles = French ares.	×	·0000386	·0000772	·0001158	·0001544	·0001930	·0002316	·0002702	·0003088	·0003474
French ares = sq. miles .	×	25899·41	51798·82	77698·23	103597·64	129497·05	155396·46	181295·87	207195·28	233094·69
Sq. miles = sq. yards .	×	·00000032	·00000064	·00000096	·00000128	·00000160	·00000192	·00000224	·00000256	·00000288
Sq. yards = sq. miles .	×	3097600	6195200	9292800	12390400	15488000	18585600	21683200	24780800	27878400
Sq. feet = sq. inches .	×	·0069444	·0138888	·0208332	·0277776	·0347220	·0416664	·0486108	·0555552	·0624996
Sq. inches = sq. feet .	×	144	288	432	576	720	864	1008	1152	1296
Sq. feet = Austrian sq. fuss	×	1·0755	2·1510	3·2265	4·3020	5·3775	6·4530	7·5285	8·6040	9·6795
Austrian sq. fuss = sq. feet	×	·92977	1·85954	2·78931	3·71908	4·64885	5·57862	6·50839	7·43816	8·36793
Sq. feet = French ares .	×	1076·410	2152·820	3229·230	4305·640	5382·050	6458·460	7534·870	8611·280	9687·690
French ares = sq. feet .	×	·000929	·001858	·002787	·003716	·004645	·005574	·006503	·007432	·008361

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (continued).

SQ. MEASURE (concluded).		1	2	3	4	5	6	7	8	9
Sq. feet = German sq. fuss	×	1·0605	2·1210	3·1815	4·2420	5·3025	6·3630	7·4235	8·4840	9·5445
German sq. fuss = sq. feet	×	·9431	1·8862	2·8293	3·7724	4·7155	5·6586	6·6017	7·5448	8·4879
Sq. feet = Swedish sq. fots	×	·9491	1·8982	2·8473	3·7964	4·7455	5·6946	6·6437	7·5928	8·5419
Swedish sq. fots = sq. feet	×	1·0537	2·1074	3·1611	4·2148	5·2685	6·3222	7·3759	8·4296	9·4833
SOLID MEASURE.										
Cu. yards = cu. feet .	×	·037037	·074074	·111111	·148148	·185185	·222222	·259259	·296296	·333333
Cu. feet = cu. yards .	×	27	54	81	108	135	162	189	216	243
Cu. yards = cu. inches .	×	·0000214	·0000428	·0000642	·0000856	·0001070	·0001284	·0001498	·0001712	·0001926
Cu. inches = cu. yards .	×	46656	93312	139968	186624	233280	279936	326592	373248	419904
Cu. yards = French stères	×	1·308	2·616	3·924	5·232	6·540	7·848	9·156	10·464	11·772
French stères = cu. yards	×	·7645	1·5290	2·2935	3·0580	3·8225	4·5870	5·3515	6·1160	6·8805
Cu. feet = cu. inches .	×	·000579	·001158	·001737	·002316	·002895	·003474	·004053	·004632	·005211
Cu. inches = cu. feet .	×	1728	3456	5184	6912	8640	10368	12096	13824	15552
Cu. feet = Austrian cu. fuss	×	1·11548	2·23096	3·34644	4·46192	5·57740	6·69288	7·80836	8·92384	10·03932
Austrian cu. fuss = cu. feet	×	·89651	1·79302	2·68953	3·58604	4·48255	5·37906	6·27557	7·17208	8·06859
Cu. feet = French stères	×	35·3156	70·6312	105·9468	141·2624	176·5780	211·8936	247·2092	282·5248	317·8404
French stères = cu. feet .	×	·02832	·05664	·08496	·11328	·14160	·16992	·19824	·22656	·25488
Cu. feet = German cu. fuss	×	1·0921	2·1842	3·2763	4·3684	5·4605	6·5526	7·6447	8·7368	9·8289
German cu. fuss = cu. feet	×	·9158	1·8316	2·7474	3·6632	4·5790	5·4948	6·4106	7·3264	8·2422
Cu. feet = Swedish cu. fots	×	·9246	1·8492	2·7738	3·6984	4·6230	5·5476	6·4722	7·3968	8·3214
Swedish cu. fots = cu. feet	×	1·0816	2·1632	3·2448	4·3264	5·4080	6·4896	7·5712	8·6528	9·7344
Cu. inches = French stères	×	61025·4	122050·8	183076·2	244101·6	305127·0	366152·4	427177·8	488203·2	549228·6
French stères = cu. inches	×	·0000164	·0000328	·0000492	·0000656	·0000820	·0000984	·0001148	·0001312	·0001476
Cu. ins. = Austrian cu. zoll	×	1·11548	2·23096	3·34644	4·46192	5·57740	6·69288	7·80836	8·92384	10·03932
Austrian cu. zoll = cu. ins.	×	·89651	1·79302	2·68953	3·58604	4·48255	5·37906	6·27557	7·17208	8·06859

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

Capacity.		1	2	3	4	5	6	7	8	9
Cu. feet = quarters	×	10·2694	20·5388	30·8082	41·0776	51·3470	61·6164	71·8858	82·1552	92·4246
Quarters = cu. feet	×	·097376	·194752	·292128	·389504	·486880	·584256	·681632	·779008	·876384
Cu. feet = bushels	×	1·2837	2·5674	3·8511	5·1848	6·4185	7·7022	8·9859	10·2696	11·5533
Bushels = cu. feet	×	·778998	1·557996	2·336994	3·115992	3·894990	4·673988	5·452986	6·231984	7·010982
Cu. feet = French litres	×	·0353156	·0706312	·1059468	·1412624	·1765780	·2118936	·2472092	·2825248	·3178404
French litres = cu. feet	×	28·3161	56·6322	84·9483	113·2644	141·5805	169·8966	198·2127	226·5288	254·8449
Cu. feet = gallons	×	·160459	·320918	·481377	·641836	·802295	·962754	1·123213	1·283672	1·444131
Gallons = cu. feet	×	6·23210	12·46420	18·69630	24·92840	31·16050	37·39260	43·62470	49·85680	56·08890
Cu. inches = gallons	×	277·274	554·548	831·822	1109·096	1386·370	1663·644	1940·918	2218·192	2495·466
Gallons = cu. inches	×	·0036065	·0072130	·0108195	·0144260	·0180325	·0216390	·0252455	·0288520	·0324585
Cu. inches = French litres	×	61·0254	122·0508	183·0762	244·1016	305·1270	366·1524	427·1778	488·2032	549·2286
French litres = cu. inches	×	·0163866	·0327732	·0491598	·0655464	·0819330	·0983196	·1147062	·1310928	·1474794
Cu. inches = quarts	×	69·3185	138·6370	207·9555	277·2740	346·5925	415·9110	485·2295	554·5480	623·8665
Quarts = cu. inches	×	·014424	·028848	·043272	·057696	·072120	·086544	·100968	·115392	·129816
Cu. inches = pints	×	34·6592	69·3184	103·9776	138·6368	173·2960	207·9552	242·6144	277·2736	311·9328
Pints = cu. inches	×	·028848	·057696	·086544	·115392	·144240	·173088	·201936	·230784	·259632
Bushels = Austrian metzen	×	1·6918	3·3836	5·0754	6·7672	8·4590	10·1508	11·8426	13·5344	15·2262
Austrian metzen = bushels	×	·591086	1·182172	1·773258	2·364344	2·955430	3·546516	4·137602	4·728688	5·319774
Bushels = French litres	×	·02751	·05502	·08253	·11004	·13755	·16506	·19257	·22008	·24759
French litres = bushels	×	36·3487	72·6974	109·0461	145·3948	181·7435	218·0922	254·4409	290·7896	327·1383
Bushels = German scheffels	×	1·5121	3·0242	4·5363	6·0484	7·5605	9·0726	10·5847	12·0968	13·6089
German scheffels = bushels	×	·661331	1·322662	1·983993	2·645324	3·306655	3·967986	4·629317	5·290648	5·951979
Bushels = Russian pajaks	×	1·4426	2·8852	4·3278	5·7704	7·2130	8·6556	10·0982	11·5408	12·9834
Russian pajaks = bushels	×	·693194	1·386388	2·079582	2·772776	3·465970	4·159164	4·852358	5·545552	6·238746
Bushels = Swedish spanns	×	2·0150	4·0300	6·0450	8·0600	10·0750	12·0900	14·1050	16·1200	18·1350
Swedish spanns = bushels	×	·496278	·992556	1·488834	1·985112	2·481390	2·977668	3·473946	3·970224	4·466502

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

Capacity (concluded).		1	2	3	4	5	6	7	8	9
Gallons = Austrian viertel	×	3·1143	6·2286	9·3429	12·4572	15·5715	18·6858	21·8001	24·9144	28·0287
Austrian viertel = gallons	×	·321099	·642198	·963297	1·284396	1·605495	1·926594	2·247693	2·568792	2·889891
Gallons = French litres	×	·220097	·440194	·660291	·880388	1·100485	1·320582	1·540679	1·760776	1·980873
French litres = gallons	×	4·451	8·902	13·353	17·804	22·255	26·706	31·157	35·608	40·059
Gallons = German ankers	×	7·559	15·118	22·677	30·236	37·795	45·354	52·913	60·472	68·031
German ankers = gallons	×	·132293	·264586	·396879	·529172	·661465	·793758	·926051	1·058344	1·190637
Gallons = Russian vedros	×	2·7049	5·4098	8·1147	10·8196	13·5245	16·2294	18·9343	21·6392	24·3441
Russian vedros = gallons	×	·3697	·7394	1·1091	1·4788	1·8485	2·2182	2·5879	2·9576	3·3273
Gallons = Swedish kannas	×	·5756	1·1512	1·7268	2·3024	2·8780	3·4536	4·0292	4·6048	5·1804
Swedish kannas = gallons	×	1·7373	3·4746	5·2119	6·9492	8·6865	10·4238	12·1611	13·8984	15·6357
Weight.										
Avoir. lbs. = quarters	×	28	56	84	112	140	168	196	224	252
Quarters = avoir. lbs.	×	·035714	·071428	·107142	·142856	·178570	·214284	·249998	·285712	·321426
Avoir. lbs. = cwts.	×	112	224	336	448	560	672	784	896	1008
Cwts. = avoir. lbs.	×	·008929	·017858	·026787	·035716	·044645	·053574	·062503	·071432	·080361
Avoir. lbs. = tons	×	2240	4480	6720	8960	11200	13440	15680	17920	20160
Tons = avoir. lbs.	×	·000446	·000892	·001338	·001784	·002230	·002676	·003122	·003568	·004014
Avoir. ozs. = pounds	×	16	32	48	64	80	96	112	128	144
Pounds = avoir. ozs.	×	·0625	·1250	·1875	·2500	·3125	·3750	·4375	·5000	·5625
Avoir. ozs. = quarters	×	448	896	1344	1792	2240	2688	3136	3584	4032
Quarters = avoir. ozs.	×	·002232	·004464	·006696	·008928	·011160	·013392	·015624	·017856	·020088
Avoir. lbs. = Austrian pfund	×	1·2352	2·4704	3·7056	4·9408	6·1760	7·4112	8·6464	9·8816	11·1168
Austrian pfund = avoir. lbs.	×	·809586	1·619172	2·428758	3·238344	4·047930	4·857516	5·667102	6·476688	7·286274
Avoir. lbs. = French kilograms	×	2·20462	4·40924	6·61386	8·81848	11·02310	13·22772	15·43234	17·63696	19·84158
French kilograms = avoir. lbs.	×	·453593	·907186	1·360779	1·814372	2·267965	2·721558	3·175151	3·628744	4·082337

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

Weight (continued).		1	2	3	4	5	6	7	8	9
Avoir. lbs. = German pfunds . .	×	1·0311	2·0622	3·0933	4·1244	5·1555	6·1866	7·2177	8·2488	9·2799
German pfunds = avoir. lbs. . .	×	·96984	1·93968	2·90952	3·87936	4·84920	5·81904	6·78888	7·75872	8·72856
Avoir. lbs. = Russian funts . .	×	·90264	1·80528	2·70792	3·61056	4·51320	5·41584	6·31848	7·22112	8·12376
Russian funts = avoir. lbs. . .	×	1·10786	2·21572	3·32358	4·43144	5·53930	6·64716	7·75502	8·86288	9·97074
Avoir. lbs. = Swedish skalpunds .	×	·9376	1·8752	2·8128	3·7504	4·6880	5·6256	6·5632	7·5008	8·4384
[illegible] vir. lbs. .	×	1·06655	2·13310	3·19965	4·26620	5·33275	6·39930	7·46585	8·53240	9·59895
[illegible] . .	×	·0005514	·0011028	·0016542	·0022056	·0027570	·0033084	·0038598	·0044112	·0049626
Austrian pfunds = tons . . .	×	1813·47	3626·94	5440·41	7253·88	9067·35	10880·82	12694·29	14507·76	16321·23
Tons = French kilograms . .	×	·0009842	·0019684	·0029526	·0039368	·0049210	·0059052	·0068894	·0078736	·0088578
French kilograms = tons . .	×	1016·05	2032·10	3048·15	4064·20	5080·25	6096·30	7112·35	8128·40	9144·45
Tons = German schiffpfunds . .	×	·151909	·303818	·455727	·607636	·759545	·911454	1·063363	1·215272	1·367181
German schiffpfunds = tons . .	×	6·58287	13·16574	19·74861	26·33148	32·91435	39·49722	46·08009	52·66296	59·24583
. .	×	·483564	·967128	1·450692	1·934256	2·417820	2·901384	3·384948	3·868512	4·352076
. .	×	2·06801	4·13602	6·20403	8·27204	12·34005	12·40806	14·47607	16·54408	18·61209
. .	×	·167429	·334858	·502287	·669716	·837145	1·004574	1·172003	1·339432	1·506861
. .	×	5·9727	11·9454	17·9181	23·8908	29·8635	35·8362	41·8089	47·7816	53·7543
of wrot. iron	×	·9277	1·8554	2·7831	3·7108	4·6385	5·5662	6·4939	7·4216	8·3493
" hard steel = " "	×	1·0179	2·0358	3·0538	4·0717	5·0896	6·1075	7·1254	8·1434	9·1613
" cast copper = " "	×	1·1207	2·2414	3·3621	4·4828	5·6035	6·7242	7·8449	8·9656	10·0863
" " brass = " "	×	1·0932	2·1864	3·2796	4·3728	5·4660	6·5592	7·6524	8·7456	9·8388
" " zinc = " "	×	·9151	1·8302	2·7453	3·6604	4·5755	5·4906	6·4057	7·3208	8·2359
" " lead = " "	×	1·4781	2·9562	4·4343	5·9124	7·3905	8·8686	10·3467	11·8248	13·3029
" soft steel = " "	×	1·0200	2·0400	3·0600	4·0800	5·1000	6·1200	7·1400	8·1600	9·1800
" sheet copper = " "	×	1·1439	2·2878	3·4317	4·5756	5·7195	6·8634	8·0073	9·1512	10·2951
" " brass = " "	×	1·0990	2·1980	3·2970	4·3960	5·4950	6·5940	7·6930	8·7920	9·8910
" " zinc = " "	×	·9493	1·8986	2·8479	3·7972	4·7465	5·6958	6·6451	7·5944	8·5437
" " lead = " "	×	1·4844	2·9688	4·4532	5·9376	7·4220	8·9064	10·3908	11·8752	[illegible]

Table of Numbers often used in Calculations multiplied by each Unit up to Nine (continued).

Weight (continued).		1	2	3	4	5	6	7	8	9
Lbs. = cu. feet of rain water . .	×	62·355	124·710	187·065	249·420	311·775	374·130	436·485	498·840	561·195
Cu. feet of rain water = lbs. . .	×	·016037	·032074	·048111	·064148	·080185	·096222	·112259	·128296	·144333
Lbs. = cu. ins. of rain water . .	×	·036085	·072170	·108255	·144340	·180425	·216510	·252595	·288680	·324765
Cu. ins. of rain water = lbs. . .	×	27·7123	55·4246	83·1369	110·8492	138·5615	166·2738	193·9861	221·6984	249·4107
Lbs. = gallons of rain water . .	×	10·0046	20·0092	30·0138	40·0184	50·0230	60·0276	70·0322	80·0368	90·0414
Gallons of rain water = lbs. . .	×	·099954	·199908	·299862	·399816	·499770	·599724	·699678	·799632	·899586
Lbs. = cu. feet of sea water . .	×	63 9762	127·9524	191·9286	255·9048	319·881 0	383·8572	447·8334	511·8096	575·7858
Cu. feet of sea water = lbs. . .	×	·015631	·031262	·046893	·062524	·078155	·093786	·109417	·125048	·140679
Lbs. = cu. ins. of sea water . .	×	·037023	·074046	·111069	·148092	·185115	·222138	·259161	·296184	·333207
Cu. ins. of sea water = lbs. . .	×	27·0102	54·0204	81·0306	108·0408	135·051 0	162·0612	189·0714	216·0816	243·0918
Lbs. = gallons of sea water . .	×	10·2647	20·5294	30·7941	41·0588	51·3235	61·5882	71·8529	82·1176	92·3823
Gallons of sea water = lbs. . .	×	·097421	·194842	·292263	·389684	·487105	·584526	·681947	·779368	·876789
Tons = cu. feet of rain water . .	×	·027837	·055674	·083511	·111348	·139185	·167022	·194859	·222696	·250533
Cu. feet of rain water = tons . .	×	35·9233	71·8466	107·7699	143·6932	179·61 65	215·5398	251·4631	287·3864	323·3097
Tons = cu. feet of sea water . .	×	·028561	·057122	·085683	·114244	·142805	·171366	·199927	·228488	·257049
Cu. feet of sea water = tons . .	×	35·013	70·026	105·039	140·052	175·065	210·078	245·091	280·104	315·117
Tons = gallons of rain water . .	×	·00447	·00894	·01341	·01788	·02235	·02682	·03129	·03576	·04023
Gallons of rain water = tons . .	×	223·897	447·794	671·691	895·588	1119·485	1343·382	1567·279	1791·176	2015·073
Tons = gallons of sea water . .	×	·004586	·009172	·013758	·018344	·022930	·027516	·032102	·036688	·041274
Gallons of sea water = tons . .	×	218·224	436·448	654·672	872·896	1091·120	1309·344	1527·568	1745·792	1964·016
Tons = Austrian cu. fuss of rain water	×	·31052	·62104	·93156	1·24208	1·55260	1·86312	2·17364	2·48416	2·79468
Austrian cu. fuss of rain water = tons	×	32·204	64·408	96·612	128·816	161·020	193·224	225·428	257·632	289·836
Tons = Austrian cu. fuss of sea water	×	·31859	·63718	·95577	1·27436	1·59295	1·91154	2·23013	2·54872	2·86731
Austrian cu. fuss of sea water = tons	×	31·388	62·776	94·164	125·552	156·940	188·328	219·716	251·104	282·492
Tons = French stères of rain water	×	·98299	1·96598	2·94897	3·93196	4·91495	5·89794	6·88093	7·86392	8·84691
French stères of rain water = tons	×	10·1780	20·3460	30·5190	40·6920	50·8650	61·0380	71·2110	81·3840	91·5570

TABLE OF NUMBERS OFTEN USED IN CALCULATIONS MULTIPLIED BY EACH UNIT UP TO NINE (concluded).

WEIGHT (concluded).		1	2	3	4	5	6	7	8	9
Tons = French stères of sea water .	×	·9914	1·9828	2·9742	3·9656	4·9570	5·9484	6·9398	7·9312	8·9226
French stères of sea water = tons .	×	1·0086	2·0172	3·0258	4·0344	5·0480	6·0516	7·0602	8·0688	9·0774
Tons = German cu. fuss of rain water	×	·0304	·0608	·0912	·1216	·1520	·1824	·2128	·2432	·2736
German cu. fuss of rain water = tons	×	32·8937	65·7874	98·6811	131·5748	164·4685	197·3622	230·2559	263·1496	296·0433
Tons = German cu. fuss of sea water	×	·03119	·06238	·09357	·12476	·15595	·18714	·21833	·24952	·28071
German cu. fuss of sea water = tons	×	32·0602	64·1204	96·1806	128·2408	160·3010	192·3612	224·4214	256·4816	288·5418
Tons = Swedish cu. fots of rain water	×	·0284	·0568	·0852	·1136	·1420	·1704	·1988	·2272	·2556
Swedish cu. fots of rain water = tons	×	35·267	70·534	105·801	141·068	176·335	211·602	246·869	282·136	317·403
Tons = Swedish cu. fots of sea water	×	·0299	·0598	·0897	·1196	·1495	·1794	·2093	·2392	·2691
Swedish cu. fots of sea water = tons	×	34·374	68·748	103·122	137·496	171·870	206·244	240·618	274·992	309·366
Lbs. = cubic feet of air . . .	×	·0755	·1510	·2265	·3020	·3775	·4530	·5285	·6040	·6795
Cubic feet of air = lbs. . . .	×	13·2485	26·4970	39·7455	52·9940	66·2425	79·4910	92·7395	105·9880	119·2365
Lbs. = cubic inches of air . .	×	1·2077	2·4154	3·6231	4·8308	6·0385	7·2462	8·4539	9·6616	10·8693
Cubic inches of air = lbs. . .	×	·82802	1·65604	2·48406	3·31208	4·14010	4·96812	5·79614	6·62416	7·45218
Lbs. on sq. in. = kilogs. on sq. centim.	×	14·2231	28·4462	42·6693	56·8924	71·1155	85·3386	99·5617	113·7848	128·0079
Kilogs. on sq. centim. = lbs. on sq. in.	×	·07031	·14062	·21093	·28124	·35155	·42186	·49217	·56248	·63279
MISCELLANEOUS NUMBERS.										
Lgth. of secs. pendulum in ins., London .		39·1393	78·2786	117·4179	156·5572	195·6965	234·8358	273·9751	313·1144	352·2537
" " " Edinburgh		39·1555	78·3110	117·4665	156·6220	195·7775	234·9330	274·0885	313·2440	352·3995
" " " Paris .		39·1293	78·2586	117·3879	156·5172	195·6465	234·7758	273·9051	313·0344	352·1637
" " " New York		39·1012	78·2024	117·3036	156·4048	195·5060	234·6072	273·7084	312·8096	351·9108
Force of gravity* in London, ft. per sec. .		32·1908	64·3816	96·5724	128·7632	160·9540	193·1448	225·3356	257·5264	289·7172
" " Edinburgh " .		32·2041	64·4082	96·6123	128·8164	161·0205	193·2246	225·4287	257·6328	289·8369
" " Paris " .		32·1826	64·3652	96·5478	128·7304	160·9130	193·0956	225·2782	257·4608	289·6434
" " New York " .		32·1595	64·3190	96·4785	128·6380	160·7975	192·9570	225·1165	257·2760	289·4355

* Gravity is generally taken at 32·2 as a mean to suit all degrees of latitude (see p. 147).

1	2		3		4		5		6		7		8		9		10	
d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.
¼		½		¾		1		1¼		1½		1¾		2		2¼		2½
½		1		1½		2		2½		3		3½		4		4½		5
¾		1½		2¼		3		3¾		4½		5¼		6		6¾		7½
1		2		3		4		5		6		7		8		9		10
1¼		2½		3¾		5		6¼		7½		8¾		10		11¼	1	0½
1½		3		4½		6		7½		9		10½	1	0	1	1½	1	3
1¾		3½		5¼		7		8¾		10½	1	0¼	1	2	1	3¾	1	5½
2		4		6		8		10	1	0	1	2	1	4	1	6	1	8
2¼		4½		6¾		9		11¼	1	1½	1	3¾	1	6	1	8¼	1	10½
2½		5		7½		10	1	0½	1	3	1	5½	1	8	1	10½	2	1
2¾		5½		8¼		11	1	1¾	1	4½	1	7¼	1	10	2	0¾	2	3½
3		6		9	1	0	1	3	1	6	1	9	2	0	2	3	2	6
3¼		6½		9¾	1	1	1	4¼	1	7½	1	10¾	2	2	2	5¼	2	8½
3½		7		10½	1	2	1	5½	1	9	2	0½	2	4	2	7½	2	11
3¾		7½		11¼	1	3	1	6¾	1	10½	2	2¼	2	6	2	9¾	3	1½
4		8	1	0	1	4	1	8	2	0	2	4	2	8	3	0	3	4
4¼		8½	1	0¾	1	5	1	9¼	2	1½	2	5¾	2	10	3	2¼	3	6½
4½		9	1	1½	1	6	1	10½	2	3	2	7½	3	0	3	4½	3	9
4¾		9½	1	2¼	1	7	1	11¾	2	4½	2	9¼	3	2	3	6¾	3	11½
5		10	1	3	1	8	2	1	2	6	2	11	3	4	3	9	4	2
5¼		10½	1	3¾	1	9	2	2¼	2	7½	3	0¾	3	6	3	11¼	4	4½
5½		11	1	4½	1	10	2	3½	2	9	3	2½	3	8	4	1½	4	7
5¾		11½	1	5¼	1	11	2	4¾	2	10½	3	4¼	3	10	4	3¾	4	9½
6	1	0	1	6	2	0	2	6	3	0	3	6	4	0	4	6	5	0
6¼	1	0½	1	6¾	2	1	2	7¼	3	1½	3	7¾	4	2	4	8¼	5	2½
6½	1	1	1	7½	2	2	2	8½	3	3	3	9½	4	4	4	10½	5	5
6¾	1	1½	1	8¼	2	3	2	9¾	3	4½	3	11¼	4	6	5	0¾	5	7½
7	1	2	1	9	2	4	2	11	3	6	4	1	4	8	5	3	5	10
7¼	1	2½	1	9¾	2	5	3	0¼	3	7½	4	2¾	4	10	5	5¼	6	0½
7½	1	3	1	10½	2	6	3	1½	3	9	4	4½	5	0	5	7½	6	3
7¾	1	3½	1	11¼	2	7	3	2¾	3	10½	4	6¼	5	2	5	9¾	6	5½
8	1	4	2	0	2	8	3	4	4	0	4	8	5	4	6	0	6	8
8¼	1	4½	2	0¾	2	9	3	5¼	4	1½	4	9¾	5	6	6	2¼	6	10½
8½	1	5	2	1½	2	10	3	6½	4	3	4	11½	5	8	6	4½	7	1
8¾	1	5½	2	2¼	2	11	3	7¾	4	4½	5	1¼	5	10	6	6¾	7	3½
9	1	6	2	3	3	0	3	9	4	6	5	3	6	0	6	9	7	6
9¼	1	6½	2	3¾	3	1	3	10¼	4	7½	5	4¾	6	2	6	11¼	7	8½
9½	1	7	2	4½	3	2	3	11½	4	9	5	6½	6	4	7	1½	7	11
9¾	1	7½	2	5¼	3	3	4	0¾	4	10½	5	8¼	6	6	7	3¾	8	1½
10	1	8	2	6	3	4	4	2	5	0	5	10	6	8	7	6	8	4
10¼	1	8½	2	6¾	3	5	4	3¼	5	1½	5	11¾	6	10	7	8¼	8	6½
10½	1	9	2	7½	3	6	4	4½	5	3	6	1½	7	0	7	10½	8	9
10¾	1	9½	2	8¼	3	7	4	5¾	5	4½	6	3¼	7	2	8	0¾	8	11½
11	1	10	2	9	3	8	4	7	5	6	6	5	7	4	8	3	9	2
11¼	1	10½	2	9¾	3	9	4	8¼	5	7½	6	6¾	7	6	8	5¼	9	4½
11½	1	11	2	10½	3	10	4	9½	5	9	6	8½	7	8	8	7½	9	7
11¾	1	11½	2	11¼	3	11	4	10¾	5	10½	6	10¼	7	10	8	9¾	9	9½

Table of Income, Wages, or Expenses.

Per Year £	s.	Per Month £	s.	d.	Per Week £	s.	d.	Per Day £	s.	d.	Per Year £	s.	Per Month £	s.	d.	Per Week £	s.	d.	Per Day £	s.	d.
1	0	0	1	8	0	0	4½	0	0	0¾	13	0	1	1	8	0	5	0	0	0	8½
1	10	0	2	6	0	0	7	0	0	1	13	13	1	2	9	0	5	3	0	0	9
2	0	0	3	4	0	0	9¼	0	0	1¼	14	0	1	3	4	0	5	4½	0	0	9¼
2	2	0	3	6	0	0	9¾	0	0	1½	14	14	1	4	6	0	5	8	0	0	9¾
2	10	0	4	2	0	0	11½	0	0	1¾	15	0	1	5	0	0	5	9	0	0	10
3	0	0	5	0	0	1	1¾	0	0	2	15	15	1	6	3	0	6	0½	0	0	10¼
3	3	0	5	3	0	1	2½	0	0	2	16	0	1	6	8	0	6	2	0	0	10½
3	10	0	5	10	0	1	4¼	0	0	2¼	16	16	1	8	0	0	6	5½	0	0	11
4	0	0	6	8	0	1	6½	0	0	2¾	17	0	1	8	4	0	6	6	0	0	11½
4	4	0	7	0	0	1	7½	0	0	2¾	17	17	1	9	9	0	6	10	0	0	11¾
4	10	0	7	6	0	1	8¾	0	0	3	18	0	1	10	0	0	6	11	0	0	11¾
5	0	0	8	4	0	1	11	0	0	3¼	18	18	1	11	6	0	7	3	0	1	0½
5	5	0	8	9	0	2	0¼	0	0	3½	19	0	1	11	8	0	7	3½	0	1	0½
5	10	0	9	2	0	2	1½	0	0	3¾	20	0	1	13	4	0	7	8	0	1	1¼
6	0	0	10	0	0	2	3¾	0	0	4	30	0	2	10	0	0	11	6	0	1	7¾
6	6	0	10	6	0	2	5	0	0	4¼	40	0	3	6	8	0	15	4½	0	2	2¼
6	10	0	10	10	0	2	6	0	0	4¼	50	0	4	3	4	0	19	3	0	2	9
7	0	0	11	8	0	2	8¼	0	0	4½	60	0	5	0	0	1	3	0¾	0	3	3½
7	7	0	12	3	0	2	10	0	0	4¾	70	0	5	16	8	1	6	11	0	3	10
7	10	0	12	6	0	2	10½	0	0	5	80	0	6	13	4	1	10	9	0	4	4½
8	0	0	13	4	0	3	1	0	0	5¼	90	0	7	10	0	1	14	7¼	0	4	11
8	8	0	14	0	0	3	2¾	0	0	5½	100	0	8	6	8	1	18	5	0	5	5¾
8	10	0	14	2	0	3	3¼	0	0	5½	200	0	16	13	4	3	16	11	0	10	11½
9	0	0	15	0	0	3	5½	0	0	6	300	0	25	0	0	5	15	4½	0	16	5¼
9	9	0	15	9	0	3	7½	0	0	6¼	400	0	33	6	8	7	13	10	1	1	11
10	0	0	16	8	0	3	10	0	0	6½	500	0	41	13	4	9	12	3½	1	7	4¾
10	10	0	17	6	0	4	0½	0	0	7	600	0	50	0	0	11	10	9	1	12	10½
11	0	0	18	4	0	4	3	0	0	7¼	700	0	58	6	8	13	9	2¾	1	18	4¼
11	11	0	19	3	0	4	5½	0	0	7½	800	0	66	13	4	15	7	8¼	2	3	10
12	0	1	0	0	0	4	7½	0	0	8	900	0	75	0	0	17	6	1¾	2	9	3¼
12	12	1	1	0	0	4	10	0	0	8¼	1,000	0	83	6	8	19	4	7¼	2	14	9½

Table of the Decimal Equivalents of Pence and Shillings.

Pence	Shillings	Pence	Shillings	Pence	Shillings	Pence	Shillings
¼	·0208333	3¼	·2708333	6¼	·5208333	9¼	·7708333
½	·0416666	3½	·2916666	6½	·5416666	9½	·7916666
¾	·0625000	3¾	·3125000	6¾	·5625000	9¾	·8125000
1	·0833333	4	·3333333	7	·5833333	10	·8333333
1¼	·1041666	4¼	·3541666	7¼	·6041666	10¼	·8541666
1½	·1250000	4½	·3750000	7½	·6250000	10½	·8750000
1¾	·1458333	4¾	·3958333	7¾	·6458333	10¾	·8958333
2	·1666666	5	·4166666	8	·6666666	11	·9166666
2¼	·1875000	5¼	·4375000	8¼	·6875000	11¼	·9375000
2½	·2083333	5½	·4583333	8½	·7083333	11½	·9583333
2¾	·2291666	5¾	·4791666	8¾	·7291666	11¾	·9791666
3	·2500000	6	·5000000	9	·7500000	12	1·0000000

Table of the Circular Measure, or Length of Circular Arc subtending any Angle, Radius being unity.

To calculate the circular measure of any angle, see 'Trigonometry' (pp. 10 and 11).

Use of the Table.—*Ex.* : Required to find the length of the circular arc subtending an angle of 40° 11′ 15″ on a circle of 560 feet radius.

Tabular No. for 40° = ·698131701
„ „ 11′ = ·003199770
„ „ 15″ = ·000072722

Length of arc = (560 × ·701404193) = 392·78634808 ft.

Seconds.

Sec.	Circ. Meas.	Sec.	Circ. Meas.	Sec.	Circ. Meas.	Sec.	Circ. Meas.
1	·0000048481	16	·0000775701	31	·0001502922	46	·0002230143
2	·0000096963	17	·0000824183	32	·0001551404	47	·0002278624
3	·0000145444	18	·0000872665	33	·0001599885	48	·0002327106
4	·0000193925	19	·0000921146	34	·0001648367	49	·0002375587
5	·0000242407	20	·0000969627	35	·0001696848	50	·0002424068
6	·0000290888	21	·0001018109	36	·0001745329	51	·0002472550
7	·0000339369	22	·0001066591	37	·0001793811	52	·0002521031
8	·0000387850	23	·0001115071	38	·0001842291	53	·0002569513
9	·0000436332	24	·0001163553	39	·0001890773	54	·0002617994
10	·0000484814	25	·0001212034	40	·0001939255	55	·0002666475
11	·0000533295	26	·0001260516	41	·0001987736	56	·0002714957
12	·0000581776	27	·0001308997	42	·0002036217	57	·0002763437
13	·0000630258	28	·0001357478	43	·0002084699	58	·0002811919
14	·0000678739	29	·0001405960	44	·0002133180	59	·0002860401
15	·0000727221	30	·0001454441	45	·0002181662	60	·0002908882

Minutes.

M.	Circ. Meas.	M.	Circ. Meas.	M.	Circ. Meas.	M.	Circ. Meas.
1	·0002908882	16	·0046542113	31	·0090175345	46	·0133808576
2	·0005817764	17	·0049450995	32	·0093084227	47	·0136717458
3	·0008726646	18	·0052359878	33	·0095993109	48	·01396263401
4	·0011635528	19	·0055268760	34	·0098901991	49	·0142535222
5	·0014544410	20	·0058177642	35	·0101810873	50	·0145444104
6	·0017453293	21	·0061086524	36	·0104719755	51	·0148352986
7	·0020362175	22	·0063995406	37	·0107628637	52	·0151261869
8	·0023271057	23	·0066904288	38	·0110537519	53	·0154170751
9	·0026179939	24	·0069813170	39	·0113446401	54	·0157079633
10	·0029088821	25	·0072722052	40	·0116355283	55	·0159988515
11	·0031997703	26	·0075630934	41	·0119264166	56	·0162897397
12	·0034906585	27	·0078539816	42	·0122173048	57	·0165806279
13	·0037815467	28	·0081448698	43	·0125081921	58	·0168715161
14	·0040724349	29	·0084357581	44	·0127990812	59	·0171624043
15	·0043633231	30	·0087266463	45	·0130899694	60	·0174532925

TABLE OF THE CIRCULAR MESAURE OF ANY ANGLE (continued).

DEGREES.

Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.
1	·017453293	46	·802851456	91	1·588249619	136	2·373647783
2	·034906585	47	·820304748	92	1·605702912	137	2·391101075
3	·052359878	48	·837758041	93	1·623156204	138	2·408554368
4	·069813170	49	·855211333	94	1·640609497	139	2·426007660
5	·087266463	50	·872664626	95	1·658062789	140	2·443460953
6	·104719755	51	·890117919	96	1·675516082	141	2·460914245
7	·122173048	52	·907571211	97	1·692969374	142	2·478367538
8	·139626340	53	·925024504	98	1·710422667	143	2·495820830
9	·157079633	54	·942477796	99	1·727875959	144	2·513274123
10	·174532925	55	·959931089	100	1·745329252	145	2·530727415
11	·191986218	56	·977384381	101	1·762782545	146	2·548180708
12	·209439510	57	·994837674	102	1·780235837	147	2·56563400
13	·226892803	58	1·012290966	103	1·797689130	148	2·583087293
14	·244346095	59	1·029744259	104	1·815142422	149	2·600540585
15	·261799388	60	1·047197551	105	1·832595715	150	2·617993878
16	·279252680	61	1·064650844	106	1·850049007	151	2·635447170
17	·296705973	62	1·082104136	107	1·867502300	152	2·652900463
18	·314159265	63	1·099557429	108	1·884955592	153	2·670353756
19	·331612558	64	1·117010721	109	1·902408885	154	2·687807048
20	·349065850	65	1·134464014	110	1·919862177	155	2·705260340
21	·366519143	66	1·151917306	111	1·937315470	156	2·722713633
22	·383972435	67	1·169370599	112	1·954768762	157	2·740166926
23	·401425728	68	1·186823891	113	1·972222055	158	2·757620218
24	·418879020	69	1·204277184	114	1·989675347	159	2·775073511
25	·436332313	70	1·221730476	115	2·007128640	160	2·792526803
26	·453785606	71	1·239183769	116	2·024581932	161	2·809980096
27	·471238898	72	1·256637061	117	2·042035225	162	2·827433388
28	·488692191	73	1·274090354	118	2·059488517	163	2·844886681
29	·506145483	74	1·291543646	119	2·076941810	164	2·862339973
30	·523598776	75	1·308996939	120	2·094395102	165	2·879793266
31	·541052068	76	1·326450232	121	2·111848395	166	2·897246558
32	·558505361	77	1·343903524	122	2·129301687	167	2·914699851
33	·575958653	78	1·361356817	123	2·146754980	168	2·932153143
34	·593411946	79	1·378810109	124	2·164208272	169	2·949606436
35	·610865238	80	1·396263402	125	2·181661565	170	2·967059728
36	·628318531	81	1·413716694	126	2·199114858	171	2·984513021
37	·645771823	82	1·431169987	127	2·216568150	172	3·001966313
38	·663225116	83	1·448623279	128	2·234021443	173	3·019419606
39	·680678408	84	1·466076572	129	2·251474735	174	3·036872898
40	·698131701	85	1·483529864	130	2·268928028	175	3·054326191
41	·715584993	86	1·500983157	131	2·286381320	176	3·071779484
42	·733038286	87	1·518436449	132	2·303834613	177	3·089232776
43	·750491578	88	1·535889742	133	2·321287905	178	3·106686069
44	·767944871	89	1·553343034	134	2·338741198	179	3·124139361
45	·785398163	90	1·570796327	135	2·356194490	180	3·141592654

TABLE OF THE CIRCULAR MEASURE OF ANY ANGLE (concluded).

DEGREES.

Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.	Deg.	Circ. Meas.
181	3·159045946	226	3·944444110	271	4·729842273	316	5·515240436
182	3·176499239	227	3·961897402	272	4·747295565	317	5·532693729
183	3·193952531	228	3·979350695	273	4·764748858	318	5·550147021
184	3·211405824	229	3·996803987	274	4·782202150	319	5·567600314
185	3·228859116	230	4·014257280	275	4·799655443	320	5·585053606
186	3·246312409	231	4·031710572	276	4·817108736	321	5·602506899
187	3·263765701	232	4·049163865	277	4·834562028	322	5·619960191
188	3·281218994	233	4·066617157	278	4·852015321	323	5·637413484
189	3·298672286	234	4·084070450	279	4·869468613	324	5·654866776
190	3·316125579	235	4·101523742	280	4·886921906	325	5·672320069
191	3·333578871	236	4·118977035	281	4·904375198	326	5·689773362
192	3·351032164	237	4·136430327	282	4·921828491	327	5·707226654
193	3·368485456	238	4·153883620	283	4·939281783	328	5·724679947
194	3·385938749	239	4·171336912	284	4·956735076	329	5·742133239
195	3·403392041	240	4·188790205	285	4·974188368	330	5·759586532
196	3·420845334	241	4·206243497	286	4·991641661	331	5·777039824
197	3·438298626	242	4·223696790	287	5·009094953	332	5·794493117
198	3·455751919	243	4·241150082	288	5·026548246	333	5·811946409
199	3·473205211	244	4·258603375	289	5·044001538	334	5·829399702
200	3·490658504	245	4·276056667	290	5·061454831	335	5·846852994
201	3·508111797	246	4·293509960	291	5·078908123	336	5·864306287
202	3·525565089	247	4·310963252	292	5·096361416	337	5·881759579
203	3·543018382	248	4·328416545	293	5·113814708	338	5·899212872
204	3·560471674	249	4·345869837	294	5·131268001	339	5·916666164
205	3·577924967	250	4·363323130	295	5·148721293	340	5·934119457
206	3·595378259	251	4·380776423	296	5·166174586	341	5·951572749
207	3·612831552	252	4·398229715	297	5·183627878	342	5·969026042
208	3·630284844	253	4·415683008	298	5·201081171	343	5·986479334
209	3·647738137	254	4·433136300	299	5·218534463	344	6·003932627
210	3·665191429	255	4·450589593	300	5·235987756	345	6·021385919
211	3·682644722	256	4·468042885	301	5·253441049	346	6·038839212
212	3·700098014	257	4·485496178	302	5·270894341	347	6·056292504
213	3·717551307	258	4·502949470	303	5·288347633	348	6·073745797
214	3·735004599	259	4·520402763	304	5·305800926	349	6·091199089
215	3·752457892	260	4·537856055	305	5·323254219	350	6·108652382
216	3·769911184	261	4·555309348	306	5·340707511	351	6·126105675
217	3·787364477	262	4·572762640	307	5·358160804	352	6·143558967
218	3·804817769	263	4·590215933	308	5·375614096	353	6·161012260
219	3·822271062	264	4·607669225	309	5·393067389	354	6·178465552
220	3·839724354	265	4·625122518	310	5·410520681	355	6·195918845
221	3·857177647	266	4·642575810	311	5·427973974	356	6·213372137
222	3·874630939	267	4·660029103	312	5·445427266	357	6·230825430
223	3·892084232	268	4·677482395	313	5·462880559	358	6·248278722
224	3·909537524	269	4·694935688	314	5·480333851	359	6·265732015
225	3·926990817	270	4·712388980	315	5·497787144	360	6·283185307

TABLE OF THE CIRCUMFERENCES AND AREAS OF CIRCLES, ADVANCING BY 8THS.

Diamr.	0		$\frac{1}{8}$		$\frac{1}{4}$		$\frac{3}{8}$		$\frac{1}{2}$		$\frac{5}{8}$		$\frac{3}{4}$		$\frac{7}{8}$		Diamr.
	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	
0	—	—	·3927	·0123	·7854	·0491	1·178	·1104	1·571	·1963	1·964	·3068	2·356	·4418	2·749	·6013	0
1	3·142	·7854	3·534	·9940	3·927	1·227	4·320	1·485	4·712	1·767	5·105	2·074	5·498	2·405	5·891	2·761	1
2	6·283	3·142	6·676	3·547	7·069	3·976	7·461	4·430	7·854	4·909	8·247	5·412	8·639	5·940	9·032	6·492	2
3	9·425	7·069	9·818	7·670	10·21	8·296	10·60	8·946	11·00	9·621	11·39	10·82	11·78	11·04	12·17	11·79	3
4	12·57	12·57	12·96	13·36	13·35	14·19	13·74	15·03	14·14	15·90	14·53	16·80	14·92	17·72	15·32	18·67	4
5	15·71	19·64	16·10	20·63	16·49	21·65	16·89	22·69	17·28	23·76	17·67	24·85	18·06	25·97	18·46	27·11	5
6	18·85	28·27	19·24	29·46	19·64	30·68	20·03	31·92	20·42	33·18	20·81	34·47	21·21	35·78	21·60	37·12	6
7	21·99	38·48	22·38	39·87	22·78	41·28	23·17	42·72	23·56	44·18	23·95	45·66	24·35	47·17	24·74	48·71	7
8	25·13	50·27	25·53	51·85	25·92	53·46	26·31	55·09	26·70	56·75	27·10	58·43	27·49	60·13	27·88	61·86	8
9	28·27	63·62	28·67	65·40	29·06	67·20	29·45	69·03	29·85	70·88	30·24	72·76	30·63	74·66	31·02	76·59	9
10	31·42	78·54	31·81	80·52	32·20	82·52	32·59	84·54	32·99	86·59	33·38	88·66	33·77	90·76	34·16	92·89	10
11	34·56	95·03	34·95	97·21	35·34	99·40	35·74	101·6	36·13	103·9	36·52	106·1	36·91	108·4	37·31	110·8	11
12	37·70	113·1	38·09	115·5	38·48	117·9	38·88	120·3	39·27	122·7	39·67	125·2	40·06	127·7	40·45	130·2	12
13	40·84	132·7	41·23	135·3	41·63	137·9	42·02	140·5	42·41	143·1	42·80	145·8	43·20	148·5	43·59	151·2	13
14	43·98	153·9	44·38	156·7	44·77	159·5	45·16	162·3	45·55	165·1	45·95	168·0	46·34	170·9	46·73	173·8	14
15	47·12	176·7	47·52	179·7	47·91	182·7	48·30	185·7	48·69	188·7	49·09	191·7	49·48	194·8	49·87	197·9	15
16	50·27	201·1	50·66	204·2	51·05	207·4	51·44	210·6	51·84	213·8	52·23	217·1	52·62	220·4	53·01	223·7	16
17	53·41	227·0	53·80	230·3	54·19	233·7	54·59	237·1	54·98	240·5	55·37	244·0	55·76	247·4	56·16	250·9	17
18	56·55	254·5	56·94	258·0	57·33	261·6	57·73	265·2	58·12	268·8	58·51	272·4	58·90	276·1	59·30	279·8	18
19	59·69	283·5	60·08	287·3	60·48	291·1	60·87	294·8	61·26	298·6	61·65	302·5	62·05	306·4	62·44	310·2	19
Diamr.	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Circm.	Area	Diamr.
	0		$\frac{1}{8}$		$\frac{1}{4}$		$\frac{3}{8}$		$\frac{1}{2}$		$\frac{5}{8}$		$\frac{3}{4}$		$\frac{7}{8}$		

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS.

Diamr.	Circumferences										Diamr.
	·0	·1	·2	·3	·4	·5	·6	·7	8	·9	
0	·0000	·3142	·6823	·9425	1·2566	1·5708	1·8850	2·1991	2·5133	2·8274	0
1	3·1416	3·4557	3·7699	4·0840	4·3982	4·7124	5·0265	5·3407	5·6548	5·9690	1
2	6·2832	6·5973	6·9115	7·2256	7·5398	7·8540	8·1681	8·4823	8·7964	9·1106	2
3	9·4248	9·7389	10·0531	10·3672	10·6814	10·9956	11·3097	11·6239	11·9380	12·2522	3
4	12·5664	12·8805	13·1947	13·5088	13·8230	14·1372	14·4513	14·7655	15·0796	15·3938	4
5	15·7080	16·0221	16·3363	16·6504	16·9646	17·2788	17·5929	17·9071	18·2212	18·5354	5
6	18·8496	19·1637	19·4779	19·7920	20·1062	20·4204	20·7345	21·0487	21·3628	21·6770	6
7	21·9912	22·3053	22·6195	22·9336	23·2478	23·5620	23·8761	24·1903	24·5044	24·8186	7
8	25·1328	25·4469	25·7611	26·0752	26·3894	26·7036	27·0177	27·3319	27·6460	27·9602	8
9	28·2744	28·5885	28·9027	29·2168	29·5310	29·8452	30·1593	30·4735	30·7876	31·1018	9
10	31·4160	31·7301	32·0443	32·3580	32·6726	32·9868	33·3009	33·6150	33·9292	34·2434	10
11	34·5576	34·8717	35·1859	35·5010	35·8142	36·1284	36·4425	36·7567	37·0708	37·3840	11
12	37·6992	38·0133	38·3275	38·6416	38·9558	39·2700	39·5841	39·8983	40·2124	40·5266	12
13	40·8408	41·1549	41·4691	41·7832	42·0974	42·4116	42·7257	43·0399	43·3540	43·6682	13
14	43·9824	44·2965	44·6107	44·9248	45·2390	45·5532	45·8673	46·1815	46·4956	46·8098	14
15	47·1240	47·4381	47·7523	48·0664	48·3806	48·6948	49·0089	49·3321	49·6372	49·9514	15
16	50·2656	50·5797	50·8939	51·2080	51·5224	51·8364	52·1505	52·4647	52·7788	53·0930	16
17	53·4072	53·7213	54·0355	54·3496	54·6038	54·9780	55·2921	55·6063	55·9204	56·2346	17
18	56·5488	56·8629	57·1771	57·4912	57·8054	58·1196	58·4337	59·7479	59·0620	59·3762	18
19	59·6904	60·0045	60·3187	60·6328	60·9470	61·2612	61·5753	61·8895	62·2036	62·5178	19
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Circumferences										

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Circumferences ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
20	62·8320	63·1461	63·4603	63·7744	64·0886	64·4028	64·7161	65·0311	65·3452	65·6594	20
21	65·9736	66·2870	66·6012	66·7916	67·2930	67·5444	67·8585	68·1727	68·4868	68·8010	21
22	69·1152	69·4293	69·7435	70·0576	70·3718	70·6860	71·0001	71·3143	71·6284	71·9426	22
23	72·2568	72·5709	72·8851	73·1992	73·5134	73·8276	74·1417	74·4559	74·7680	75·0882	23
24	75·3984	75·7125	76·0267	76·3408	76·6523	76·9692	77·2833	77·5975	77·9116	78·2258	24
25	78·5400	78·8541	79·1683	79·4824	79·7966	80·8108	80·4249	80·7391	81·0532	81·3674	25
26	81·6816	82·3099	82·6240	82·6240	82·9382	83·2524	83·5665	83·8807	84·1948	84·5090	26
27	84·8232	85·1373	85·4515	85·7656	86·0798	86·3940	86·7081	87·0223	87·3364	87·6506	27
28	87·9648	88·2789	88·5931	88·9072	89·2214	89·5315	89·8497	90·1639	90·4780	90·7922	28
29	91·1064	91·4205	91·7347	92·0488	92·3630	92·6772	92·9913	93·3055	93·6196	93·9338	29
30	94·2480	94·5621	94·8763	95·1904	95·5046	95·8188	96·1329	96·4471	96·7612	97·0754	30
31	97·3896	97·7037	98·0179	98·3320	98·6452	98·9604	99·2745	99·5887	99·9028	100·217	31
32	100·531	100·845	101·160	101·474	101·748	102·102	102·416	102·730	103·044	103·359	32
33	103·673	103·987	104·301	104·615	104·929	105·244	105·558	105·872	106·186	106·500	33
34	106·814	107·129	107·427	107·757	108·071	108·385	108·699	109·035	109·308	109·642	34
35	109·956	110·270	110·584	110·898	112·213	111·527	111·841	112·155	112·469	112·783	35
36	113·098	113·412	113·726	114·040	114·354	114·668	114·983	115·297	115·611	115·925	36
37	116·239	116·553	116·868	117·182	117·496	117·810	118·124	118·438	118·752	119·067	37
38	119·381	119·695	120·009	120·323	120·637	120·952	121·266	121·580	121·894	122·208	38
39	122·522	122·837	123·151	123·465	123·779	124·093	124·407	124·722	125·036	125·350	39
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Circumferences										

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Circumferences ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
40	125·664	125·978	126·292	126·606	126·921	127·235	127·549	127·863	128·177	128·491	40
41	128·806	129·120	129·432	129·748	130·062	130·376	130·691	131·005	131·319	131·632	41
42	131·947	132·261	132·576	132·890	133·204	133·518	133·832	134·146	134·460	134·775	42
43	135·089	135·403	135·717	136·033	136·345	136·660	136·974	137·288	137·602	137·916	43
44	138·230	138·545	138·859	139·173	139·487	139·801	140·115	140·430	140·744	141·058	44
45	141·372	141·686	142·000	142·314	142·629	142·943	143·257	143·571	143·885	144·199	45
46	144·514	144·828	145·142	145·456	145·770	146·084	146·399	146·713	147·027	147·341	46
47	147·655	147·969	148·284	148·598	148·912	149·226	149·536	149·854	150·168	150·483	47
48	150·797	151·111	151·425	151·739	152·053	152·368	152·682	152·996	153·310	153·624	48
49	153·938	154·253	154·567	154·881	155·195	155·509	155·823	156·138	156·452	156·756	49
50	157·080	157·394	157·708	158·022	158·337	158·651	158·965	159·279	159·593	159·907	50
51	160·222	160·536	160·850	161·164	161·478	161·792	162·107	162·421	162·734	163·049	51
52	163·363	163·677	163·994	164·306	164·620	164·934	165·248	165·562	165·876	166·191	52
53	166·505	166·819	167·133	167·447	167·761	168·076	168·390	168·705	169·018	169·332	53
54	169·646	169·961	170·275	170·589	170·903	171·217	171·531	171·846	172·160	172·474	54
55	172·788	173·102	173·416	173·730	174·045	174·359	174·673	174·977	175·309	175·615	55
56	175·930	176·244	176·558	176·872	177·186	177·500	177·815	178·129	178·443	178·757	56
57	179·071	179·385	179·700	180·014	180·328	180·642	180·956	181·280	181·584	181·899	57
58	182·213	182·527	182·841	183·155	183·469	183·784	184·098	184·412	184·726	185·040	58
59	185·354	185·669	185·983	186·270	186·611	186·925	187·239	187·554	187·868	188·182	59
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Circumferences										

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Circumferences										Diamr.
	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	
60	188·496	188·810	189·124	189·438	189·753	190·067	190·381	190·695	191·009	191·323	60
61	191·638	191·952	192·266	192·580	192·894	193·208	193·523	193·837	194·151	194·465	61
62	194·779	195·093	195·408	195·722	196·036	196·350	196·664	196·978	197·292	197·607	62
63	197·921	198·235	198·549	198·863	199·177	199·492	199·806	200·120	200·434	200·748	63
64	201·062	201·377	201·691	202·005	202·319	202·633	202·947	203·262	203·576	203·890	64
65	204·204	204·518	204·832	205·146	205·461	205·775	206·089	206·403	206·717	207·031	65
66	207·346	207·660	207·974	208·288	208·602	208·916	209·231	209·545	209·859	210·173	66
67	210·487	210·801	211·116	211·430	211·744	212·058	212·372	212·686	213·000	213·315	67
68	213·629	213·943	214·257	214·571	214·885	215·200	215·514	215·828	216·142	216·456	68
69	216·770	217·085	217·399	217·713	218·027	218·341	218·655	218·970	219·284	219·598	69
70	219·912	220·226	220·540	220·854	221·169	221·483	221·797	222·111	222·425	222·739	70
71	223·054	223·368	223·682	223·996	224·310	224·624	224·939	225·253	225·567	225·881	71
72	226·195	226·509	226·824	227·138	227·452	227·766	228·080	228·394	228·708	229·023	72
73	229·337	229·651	229·965	230·279	230·593	230·908	231·222	231·536	231·850	232·164	73
74	232·478	232·793	233·107	233·421	233·735	234·049	234·363	234·678	234·992	235·306	74
75	235·620	235·934	236·248	236·562	236·877	237·191	237·505	237·819	238·133	238·447	75
76	238·762	239·076	239·390	239·704	240·018	240·332	240·647	240·961	241·275	241·599	76
77	241·903	242·217	242·532	242·846	243·160	243·474	243·788	244·102	244·416	244·731	77
78	245·045	245·359	245·673	245·987	246·301	246·616	246·930	247·244	247·548	247·872	78
79	248·186	248·501	248·815	249·129	249·443	249·757	250·071	250·386	250·700	251·014	79
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Circumferences										

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 10THS (concluded).

Diamr.	Circumferences ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
80	251·328	251·624	251·956	252·270	252·585	252·899	253·213	253·527	253·841	254·155	80
81	254·470	254·784	255·098	255·412	255·726	256·040	256·355	256·669	256·983	257·297	81
82	257·611	257·925	258·240	258·554	258·865	259·182	259·496	259·810	260·124	260·439	82
83	260·753	261·067	261·381	261·695	262·009	262·324	262·638	262·952	263·264	263·580	83
84	263·894	264·209	264·523	264·837	265·151	265·465	265·779	266·094	266·408	266·722	84
85	267·036	267·350	267·664	267·978	268·293	268·607	268·921	269·235	269·549	269·863	85
86	270·178	270·492	270·806	271·120	271·434	271·748	272·067	272·377	272·691	273·005	86
87	273·319	273·633	273·988	274·262	274·576	274·890	275·204	275·518	275·832	276·147	87
88	276·461	276·775	277·089	277·403	277·717	278·032	278·346	278·660	278·975	279·288	88
89	279·602	279·917	280·231	280·545	280·859	281·173	281·487	281·883	282·116	282·430	89
90	282·744	283·058	283·372	283·686	284·001	284·315	284·629	284·943	285·257	285·571	90
91	285·886	286·200	286·514	286·829	287·142	287·456	287·771	288·085	288·399	288·713	91
92	289·027	289·341	289·656	289·970	290·284	290·598	290·912	291·226	291·540	291·855	92
93	292·169	292·483	292·797	293·111	293·425	293·740	294·054	294·368	294·682	294·996	93
94	295·310	295·625	295·939	296·244	296·567	296·881	297·195	297·510	297·824	298·138	94
95	298·452	298·766	299·072	299·394	299·709	300·023	300·337	300·651	300·965	301·279	95
96	301·594	301·908	302·222	302·536	302·850	303·164	303·479	303·793	304·107	304·421	96
97	304·735	305·049	305·364	305·678	305·992	306·306	306·620	306·936	307·248	307·563	97
98	307·877	308·191	308·505	308·819	309·133	309·448	309·762	310·076	310·396	310·704	98
99	311·018	311·333	311·647	311·961	312·275	312·589	312·903	313·218	313·512	313·846	99
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Circumferences										

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS.

Diamr.	Areas ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
0	·0000	·0078	·0314	·0706	·1256	·1963	·2827	·3848	·5026	·6361	0
1	·7854	·9503	1·1309	1·3273	1·5393	1·7671	2·0106	2·2698	2·5446	2·8352	1
2	3·1416	3·4636	3·8013	4·1547	4·5239	4·9087	5·3093	5·7255	6·1575	6·6052	2
3	7·0686	7·5476	8·0424	8·5530	9·0792	9·6211	10·1787	10·7521	11·3411	11·9459	3
4	12·5664	13·2025	13·8544	14·5220	15·2053	15·9043	16·6190	17·3494	18·0956	18·8574	4
5	19·6350	20·4282	21·2372	22·0618	22·9022	23·7583	24·6301	25·5176	26·4208	27·3397	5
6	28·2744	29·2247	30·1907	31·1725	32·1699	33·1831	34·2120	35·2566	36·3168	37·3928	6
7	38·4846	39·5920	40·7151	41·8539	43·0085	44·1787	45·3647	46·5663	47·7837	49·0168	7
8	50·2656	51·5300	52·8102	54·1062	55·4178	56·7451	58·0881	59·4469	60·8213	62·2115	8
9	63·6174	65·0389	66·4762	67·9292	69·3979	70·8823	72·3824	73·8982	75·4298	76·9770	9
10	78·5400	80·1186	81·7130	83·2320	84·9488	86·5903	88·2475	89·9204	91·6090	93·3133	10
11	95·0334	96·7691	98·5205	100·2877	102·0705	103·8691	105·6834	107·5134	109·3590	111·2204	11
12	113·0976	114·9904	116·8989	118·8231	120·7631	122·7187	124·6901	126·6771	128·6799	130·6984	12
13	132·7326	134·7824	136·8480	138·9294	141·0264	143·1391	145·2675	147·4117	149·5715	151·7471	13
14	153·9384	156·1453	158·3680	160·6064	162·8605	165·1303	167·4158	169·7170	172·0340	174·3666	14
15	176·7150	179·0790	181·4588	183·8542	186·2654	188·6923	191·1349	193·5932	196·0672	198·5569	15
16	201·0624	203·5835	206·1209	208·6723	211·1411	213·8251	216·4248	219·0402	221·6712	224·3189	16
17	226·9086	229·6588	232·3527	235·0623	237·7877	240·5287	243·2855	246·0579	248·8461	251·6500	17
18	254·4696	257·3048	260·1558	263·0226	265·9050	268·8031	271·7169	274·6465	277·5917	280·5527	18
19	283·5294	286·5217	289·5298	292·5536	295·5931	298·6483	301·7192	304·8060	307·9082	311·0252	19
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Areas										

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Areas ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
20	314·1600	317·3094	320·4746	323·6554	326·8520	330·0643	333·2923	336·3360	339·7954	343·0705	20
21	346·3614	349·6679	352·9901	356·3281	359·6817	363·0511	366·4362	369·8370	373·2534	376·6856	21
22	380·1336	383·5972	387·0765	390·5751	394·0823	397·6087	401·1509	404·7087	408·2823	411·8716	22
23	415·4766	419·0972	422·7336	426·3858	430·0536	433·7371	437·4363	441·1511	444·8819	448·6283	23
24	452·3904	456·1681	459·9616	463·7708	467·5957	471·4363	475·2926	479·1646	483·0524	486·9558	24
25	490·8750	494·8098	498·7604	502·7266	506·7086	510·7063	514·7196	518·7488	522·7936	526·8541	25
26	530·9304	535·0223	539·1299	543·2533	547·3923	551·5471	555·7176	559·9038	564·1056	568·3232	26
27	572·5566	576·8056	581·0703	585·3507	589·6469	593·9587	598·2863	602·6295	606·9885	611·3632	27
28	615·7536	620·1596	624·5814	629·0190	633·4722	637·9411	642·4257	646·9261	651·4421	655·9739	28
29	660·5214	665·0845	669·6634	674·2580	678·8683	683·4943	688·1360	692·7934	697·4666	702·1554	29
30	706·8600	711·5802	716·3162	721·0678	725·8352	730·6183	735·4171	740·2316	745·0618	749·9077	30
31	754·7694	759·6467	764·5397	769·4485	774·3729	779·3131	784·2689	789·2406	794·2278	799·2308	31
32	804·2496	809·2840	814·3341	819·3999	824·4815	829·5787	834·6917	839·8203	844·9647	850·1248	32
33	855·3006	860·4920	865·6992	870·9222	876·1608	881·4151	886·6851	891·9709	897·2723	902·5895	33
34	907·9224	913·2709	918·6352	924·0115	929·4109	934·8223	940·2494	945·6922	951·1508	956·6250	34
35	962·1150	967·6206	973·1420	978·6790	984·2318	989·8003	995·3845	1000·984	1006·600	1012·231	35
36	1017·878	1023·541	1029·220	1034·913	1040·624	1046·349	1052·090	1057·8474	1063·620	1069·408	36
37	1075·213	1081·032	1086·868	1092·719	1098·586	1104·469	1110·367	1116·281	1122·211	1128·156	37
38	1134·118	1140·095	1146·087	1152·095	1158·119	1164·159	1170·215	1176·286	1182·373	1188·465	38
39	1194·539	1200·727	1206·877	1213·042	1219·224	1225·420	1231·633	1237·861	1244·121	1250·365	39
Diamr.	·0 Areas	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Areas ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
40	1256·640	1262·931	1269·239	1275·560	1281·898	1288·252	1294·622	1301·007	1307·408	1313·825	40
41	1320·257	1326·706	1333·169	1339·649	1346·144	1352·655	1359·182	1365·724	1372·282	1378·856	41
42	1385·446	1392·051	1398·672	1405·308	1411·961	1418·629	1425·313	1432·012	1438·727	1445·458	42
43	1452·205	1458·967	1465·745	1472·539	1479·348	1486·173	1493·014	1499·871	1506·743	1513·629	43
44	1520·534	1527·454	1534·389	1541·340	1548·306	1555·288	1562·286	1569·300	1576·329	1583·374	44
45	1590·435	1597·511	1604·604	1611·711	1618·835	1625·974	1633·129	1640·302	1647·486	1654·689	45
46	1661·906	1669·140	1676·389	1683·654	1690·935	1698·231	1705·543	1712·871	1720·214	1727·574	46
47	1734·949	1742·339	1749·746	1757·168	1764·605	1772·059	1779·528	1787·013	1794·513	1802·030	47
48	1809·562	1817·109	1824·673	1832·252	1839·847	1847·457	1855·083	1862·725	1870·383	1878·056	48
49	1885·745	1893·450	1901·171	1908·907	1916·659	1924·426	1932·210	1940·009	1947·823	1955·654	49
50	1963·500	1971·362	1979·239	1987·133	1995·042	2002·966	2010·907	2018·863	2026·835	2034·877	50
51	2042·825	2050·844	2058·878	2066·929	2074·995	2083·077	2091·175	2099·288	2107·417	2115·561	51
52	2123·722	2131·898	2140·089	2148·297	2156·520	2164·759	2173·013	2181·284	2189·570	2197·871	52
53	2206·189	2214·522	2222·870	2231·235	2239·615	2248·011	2256·423	2264·870	2273·293	2281·752	53
54	2290·226	2298·717	2307·222	2315·744	2324·281	2332·834	2341·403	2349·987	2358·588	2367·203	54
55	2375·835	2384·482	2393·145	2401·824	2410·518	2419·228	2427·954	2436·696	2445·453	2454·226	55
56	2463·014	2471·819	2480·639	2489·475	2498·326	2507·193	2516·076	2524·974	2533·889	2542·819	56
57	2551·765	2560·726	2569·703	2578·696	2587·705	2596·729	2605·769	2614·824	2623·896	2632·983	57
58	2642·086	2651·205	2660·338	2669·488	2678·654	2687·835	2697·032	2706·245	2715·473	2724·718	58
59	2733·977	2743·253	2752·544	2761·851	2771·174	2780·512	2789·866	2799·236	2808·622	2818·023	59
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (continued).

Diamr.	Areas ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
60	2827·440	2836·873	2846·321	2855·785	2865·265	2874·760	2884·262	2893·798	2903·341	2912·899	60
61	2922·473	2932·063	2941·669	2957·290	2960·927	2970·579	2980·247	2989·931	2999·630	3009·346	61
62	3019·078	3028·824	3038·587	3048·365	3058·159	3067·969	3077·794	3087·634	3097·492	3107·364	62
63	3117·253	3127·156	3137·076	3147·011	3156·966	3166·929	3176·912	3186·910	3196·924	3206·953	63
64	3216·998	3227·059	3237·136	3247·228	3257·337	3267·460	3277·600	3287·755	3297·926	3308·113	64
65	3318·315	3328·534	3338·767	3349·016	3359·281	3369·562	3379·859	3390·171	3400·499	3410·843	65
66	3421·202	3431·578	3441·963	3452·375	3462·797	3473·235	3483·689	3494·164	3504·643	3515·143	66
67	3525·661	3536·193	3546·741	3557·304	3567·884	3578·479	3589·090	3599·716	3610·358	3621·016	67
68	3631·690	3642·379	3653·084	3663·804	3674·541	3685·293	3696·006	3706·845	3717·644	3728·459	68
69	3739·289	3750·136	3760·998	3771·876	3782·769	3793·678	3804·603	3815·544	3826·500	3837·472	69
70	3848·460	3859·495	3870·483	3881·517	3892·568	3903·634	3914·716	3925·814	3936·927	3948·057	70
71	3959·201	3970·362	3981·538	3992·730	4003·937	4015·161	4026·400	4037·655	4048·925	4060·212	71
72	4071·514	4082·833	4094·165	4105·513	4116·879	4128·259	4139·652	4151·067	4162·494	4173·938	72
73	4185·397	4196·871	4208·361	4219·868	4231·390	4242·927	4254·480	4266·049	4277·634	4289·234	73
74	4300·850	4312·482	4324·130	4335·793	4347·472	4359·166	4370·877	4382·603	4394·345	4406·102	74
75	4417·875	4429·664	4441·468	4453·289	4465·125	4476·976	4488·844	4500·727	4512·626	4524·540	75
76	4536·470	4548·416	4560·379	4572·355	4584·358	4596·357	4608·382	4620·422	4632·478	4644·549	76
77	4656·637	4668·740	4680·858	4692·993	4705·143	4717·309	4729·490	4741·688	4753·961	4766·129	77
78	4778·374	4790·634	4802·909	4815·201	4827·508	4839·831	4852·170	4864·524	4876·897	4889·280	78
79	4901·681	4914·099	4926·531	4938·982	4951·444	4963·924	4976·484	4988·931	5001·459	5014·001	79
Diamr.	Areas ·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 10THS (concluded).

Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Areas										
80	5026·560	5039·134	5051·724	5064·330	5076·955	5089·588	5102·241	5114·910	5127·594	5140·294	80
81	5153·009	5165·741	5178·488	5191·251	5204·029	5216·823	5229·633	5242·459	5255·300	5268·157	81
82	5281·030	5293·918	5306·822	5319·744	5332·678	5345·629	5358·596	5371·598	5384·576	5397·591	82
83	5410·621	5423·666	5436·727	5449·804	5462·897	5476·005	5489·129	5502·269	5515·424	5528·596	83
84	5541·702	5554·985	5568·203	5581·437	5594·687	5607·952	5621·233	5634·568	5647·843	5661·171	84
85	5674·515	5687·875	5701·250	5714·641	5728·048	5741·470	5754·909	5768·362	5781·832	5795·317	85
86	5808·818	5822·335	5835·868	5849·416	5862·980	5876·559	5890·154	5903·765	5917·392	5931·034	86
87	5944·693	5958·364	5972·056	5985·769	5999·482	6013·219	6026·971	6040·739	6054·515	6068·322	87
88	6082·138	6095·968	6109·815	6123·677	6137·555	6151·449	6165·359	6179·284	6193·225	6207·181	88
89	6221·153	6235·141	6249·145	6263·164	6277·200	6291·204	6305·317	6319·399	6333·497	6347·681	89
90	6361·740	6375·885	6390·046	6404·222	6418·414	6432·622	6446·844	6461·085	6475·340	6489·611	90
91	6503·897	6518·200	6532·517	6546·891	6561·208	6575·565	6589·946	6604·322	6618·754	6633·182	91
92	6647·626	6662·085	6676·560	6691·016	6705·557	6720·079	6734·617	6749·170	6763·739	6778·324	92
93	6792·925	6807·541	6822·173	6836·821	6851·484	6866·163	6880·858	6895·569	6910·295	6925·037	93
94	6939·794	6954·568	6969·357	6984·161	6998·982	7013·818	7028·670	7043·503	7058·418	7073·320	94
95	7088·235	7103·165	7118·112	7133·073	7148·051	7163·044	7178·053	7193·078	7208·118	7223·175	95
96	7238·246	7253·334	7268·437	7283·556	7298·691	7313·841	7329·007	7344·189	7359·386	7374·600	96
97	7389·829	7405·073	7420·334	7435·610	7450·901	7466·209	7481·532	7496·871	7512·225	7527·596	97
98	7542·982	7558·383	7573·801	7589·234	7604·683	7620·147	7635·627	7651·193	7666·635	7682·162	98
99	7697·705	7713·264	7728·839	7744·429	7760·035	7775·656	7791·294	7806·947	7822·615	7838·300	99
Diamr.	·0	·1	·2	·3	·4	·5	·6	·7	·8	·9	Diamr.
	Areas										

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 12THS.

Diamr.	Circumferences 0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	Diamr.
0	·00000	·26180	·52360	·78540	1·0472	1·3090	1·5708	1·8326	2·0944	2·3562	2·6180	2·8798	0
1	3·1416	3·4034	3·6652	3·9270	4·1888	4·4506	4·7124	4·9742	5·2360	5·4978	5·7596	6·0214	1
2	6·2832	6·5450	6·8068	7·0686	7·3304	7·5922	7·8540	8·1158	8·3776	8·6394	8·9012	9·1630	2
3	9·4248	9·6866	9·9484	10·2102	10·4720	10·7338	10·9956	11·2574	11·5192	11·7810	12·0428	12·3046	3
4	12·5664	12·8282	13·0900	13·3518	13·6136	13·8754	14·1372	14·3990	14·6608	14·9226	15·1844	15·4462	4
5	15·7080	15·9698	16·2316	16·4934	16·7552	17·0170	17·2788	17·5406	17·8024	18·0642	18·3260	18·5878	5
6	18·8496	19·1114	19·3732	19·6350	19·8968	20·1586	20·4204	20·6822	20·9440	21·2058	21·4676	21·7294	6
7	21·9912	22·2530	22·5148	22·7766	23·0384	23·3002	23·5620	23·8238	24·0856	24·3474	24·6092	24·8710	7
8	25·1328	25·3946	25·6564	25·9182	26·1800	26·4418	26·7036	26·9654	27·2272	27·4890	27·7508	28·0126	8
9	28·2744	28·5362	28·7980	29·0598	29·3216	29·5834	29·8452	30·1070	30·3688	30·6306	30·8924	31·1542	9
10	31·4160	31·6778	31·9396	32·2014	32·4632	32·7250	32·9868	32·2486	33·5104	33·7722	34·0340	34·2958	10
11	34·5576	34·8194	35·0812	35·3430	35·6048	35·8666	36·1284	36·3902	36·6520	36·9138	37·1756	34·4374	11
12	37·6992	37·9610	38·2228	38·4846	38·7464	39·0082	39·2700	39·5318	39·7936	40·0554	40·3172	40·5790	12
13	40·8408	41·1026	41·3644	41·6262	41·8880	42·1498	42·4116	42·6734	42·9352	43·1970	43·4588	43·7206	13
14	43·9824	44·2442	44·5060	44·7678	45·0296	45·2914	45·5532	45·8150	46·0678	46·3386	46·6004	46·8622	14
15	47·1240	47·3858	47·6476	47·9094	48·1712	48·4330	48·6948	48·9566	49·2184	49·4802	49·7420	50·0038	15
16	50·2656	50·5274	50·7892	51·0510	51·3128	51·5746	51·8364	52·0982	52·3600	52·6218	52·8836	53·1454	16
17	53·4072	53·6690	53·9308	54·1926	54·4544	54·7162	54·9780	55·2398	55·5016	55·7634	56·0252	56·2870	17
18	56·5488	56·8106	57·0724	57·3342	57·5960	57·8578	58·1196	58·3814	58·6432	58·9050	59·1668	59·4286	18
19	59·6904	59·9522	60·2140	60·4758	60·7376	60·9994	61·2612	61·5230	61·7848	62·0466	62·3084	62·5702	19
Diamr.	0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	Diamr.
	Circumferences												

TABLE OF THE CIRCUMFERENCES OF CIRCLES, ADVANCING BY 12THS (concluded).

Diamr.	0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	Diamr.
	Circumferences												
20	62·8320	63·0938	63·3556				64·4028	64·6646	64·9264	65·1882	65·4500	65·7118	20
21	65·9736	66·2354	66·4972				67·5444	67·8062	68·0680	68·3298	68·5916	68·8534	21
22	69·1152	69·3770	69·6388				70·6860	70·9478	71·2096	71·4714	71·7332	71·9950	22
23	72·2568	72 5186	72·7804				73·8276	74·0894	74·3512	74·6130	74·8748	75·1366	23
24	75·3984	75·6602	75·9220				76·9692	77·2310	77·4928	77·7546	78·0164	78·2782	24
25	78·5400	78·8018	79·0636				80·1108	80·3726	80·6344	80·8962	81·1580	81·4198	25
26	81·6816	81·9434	82·2052				83·2524	83·5142	83·7760	84·0378	84·2996	84·5614	26
27	84·8232	85·0850	85·3468				86·3940	86·6558	86·9176	87 1794	87·4412	87·7030	27
28	87·9648	88·2266	88·4884				89·5356	89·7974	90·0592	90·3210	90·5828	90·8446	28
29	91·1064	91·3682	91·6300				92·6772	92·9390	93·2008	93·4626	93·7244	93·9862	29
30	94·2480	94·5098	94·7716				95·8186	96·0806	96·3424	96·6042	96·8660	92·1278	30
31	97·3896	97·6514	97·9132				98·9604	99·2222	99·4840	99·7458	100·008	100·269	31
32	100·531	100·793	101·055				102·102	102·364	102·626	102·887	103·149	103·411	32
33	103·673	103·935	104·196				105·244	105·505	105·767	106·029	106·291	106·553	33
34	106·814	107·076	107·338				108·385	108·647	108 909	109·171	109·432	109·694	34
35	109·956	110·218	110·480				111·527	111·789	112·050	112·312	112·574	112·836	35
36	113·098	113·359	113·621				114·668	114·930	115·192	115·454	115·776	115·977	36
37	116·239	116 501	116·763				117·810	118·072	118·334	118·595	118·857	119·119	37
38	119·381	119·643	119·904				120 952	121·213	121·475	121·737	121·999	122·261	38
39	122·522	122·784	123·046				124·093	124·355	124·617	124·879	125·140	125·402	39
Diamr.	0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	Diamr.
	Circumferences												

Table of the Areas of Circles, advancing by 12ths.

Diamr.	Areas 0	1/12	2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	Diamr.
0	·0000	·0055	·0218	·0491	·0873	·1364	·1963	·2673	·3491	·4418	·5454	·6600	0
1	·7854	·9218	1·0690	1·2272	1·3963	1·5763	1·7671	1·9689	2·1817	2·4053	2·6398	2·8852	1
2	3·1416	3·4088	3·6870	3·9761	4·2761	4·5869	4·9087	5·2414	5·5851	5·9396	6·3050	6·6813	2
3	7·0686	7·4667	7·8758	8·2958	8·7266	9·1684	9·6211	10·0847	10·5592	11·0447	11·5410	12·0482	3
4	12·5664	13·0954	13·6354	14·1863	14·7480	15·3207	15·9043	16·4988	17·1042	17·7205	18·3478	18·9859	4
5	19·6350	20·2949	20·9658	21·6475	22·3402	23·0438	23·7583	24·4837	25·2200	25·9672	26·7254	27·4944	5
6	28·2743	29·0652	29·8669	30·6796	31·5032	32·3377	33·1831	34·0394	34·9066	35·7847	36·6737	37·5737	6
7	38·4846	39·4063	40·3389	41·2825	42·2370	43·2024	44·1786	45·1658	46·1640	47·1730	48·1929	49·2237	7
8	50·2655	51·3181	52·3817	53·4562	54·5415	55·6378	56·7450	57·8631	58·9921	60·1320	61·2829	62·4446	8
9	63·6173	64·8008	65·9953	67·2006	68·4169	69·6441	70·8822	72·1312	73·3911	74·6619	75·9436	77·2363	9
10	78·5398	79·8543	81·1796	82·5159	83·8631	85·2212	86·5901	87·9700	89·3609	90·7626	92·1752	93·5987	10
11	95·0332	96·4785	97·9348	99·4020	100·880	102·369	103·869	105·380	106·901	108·434	109·978	111·532	11
12	113·097	114·674	116·261	117·859	119·468	121·088	122·719	124·360	126·013	127·676	129·351	131·036	12
13	132·732	134·439	136·158	137·887	139·626	141·377	143·139	144·911	146·695	148·489	150·295	152·111	13
14	153·938	155·776	157·625	159·485	161·356	163·237	165·130	167·034	168·948	170·873	172·809	174·757	14
15	176·715	178·684	180·663	182·654	184·656	186·663	188·692	190·726	192·772	194·828	196·895	198·973	15
16	201·062	203·162	205·273	207·394	209·527	211·670	213·825	215·990	218·166	220·353	222·551	224·760	16
17	226·980	229·211	231·453	233·705	235·969	238·243	240·528	242·824	245·132	247·450	249·778	252·118	17
18	254·469	256·831	259·203	261·587	263·981	266·386	268·803	271·230	273·668	276·117	278·576	281·047	18
19	283·529	286·021	288·525	291·039	293·564	296·111	298·648	301·206	303·775	306·354	308·945	311·547	19
Diamr.	0	1/12	2/12	3/12	4/12	5/12	6/12	7/12	8/12	9/12	10/12	11/12	Diamr.
	Areas												

TABLE OF THE AREAS OF CIRCLES, ADVANCING BY 12THS (concluded).

Diamr.	Areas												Diamr.
	0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	
20	314·159	316·783	319·417	322·062	324·719	327·386	330·064	332·753	335·452	338·163	340·885	343·617	20
21	346·361	349·115	351·880	354·656	357·443	360·241	363·050	365·870	368·701	371·542	374·395	377·258	21
22	380·133	383·018	385·914	388·821	391·739	394·668	397·608	400·559	403·520	406·493	409·476	412·470	22
23	415·476	418·492	421·519	424·557	427·606	430·665	433·736	436·818	439·910	443·014	446·128	449·253	23
24	452·389	455·536	458·694	461·863	465·043	468·234	471·435	474·648	477·871	481·106	484·351	487·607	24
25	490·874	494·152	497·441	500·740	504·051	507·373	510·705	514·049	517·403	520·768	524·144	527·531	25
26	530·929	534·338	537·758	541·188	544·630	548·083	551·546	555·020	558·505	562·002	565·509	569·026	26
27	572·555	576·095	579·646	583·207	586·780	590·363	593·957	597·563	601·179	604·806	608·444	612·092	27
28	615·752	619·423	623·104	626·797	630·500	634·215	637·940	641·676	645·423	649·181	652·950	656·729	28
29	660·520	664·321	668·134	671·957	675·792	679·637	683·493	687·360	691·238	695·127	699·026	702·937	29
30	706·858	710·791	714·734	718·688	722·654	726·630	730·617	734·615	738·623	742·643	746·674	750·715	30
31	754·768	758·831	762·905	766·990	771·087	775·193	779·311	783·440	787·580	791·730	795·892	800·064	31
32	804·248	808·442	812·647	816·863	821·090	825·328	829·577	833·837	838·107	842·389	846·681	850·984	32
33	855·299	859·624	863·960	868·307	872·665	877·033	881·413	885·804	890·205	894·618	899·041	903·475	33
34	907·920	912·376	916·843	921·321	925·810	930·310	934·820	939·342	943·874	948·417	952·972	957·537	34
35	962·113	966·700	971·298	975·906	980·526	985·157	989·798	994·450	999·114	1003·79	1008·47	1013·17	35
36	1017·88	1022·59	1027·32	1032·06	1036·81	1041·57	1046·35	1051·13	1055·92	1060·73	1060·55	1070·37	36
37	1075·21	1080·06	1084·92	1089·79	1094·67	1099·56	1104·47	1109·38	1114·31	1119·24	1124·19	1129·15	37
38	1134·11	1139·09	1144·09	1149·09	1154·10	1159·12	1164·16	1169·20	1174·26	1179·32	1184·40	1189·49	38
39	1194·59	1199·70	1204·82	1209·96	1215·10	1220·25	1225·42	1230·59	1235·78	1240·98	1246·19	1251·41	39
Diamr.	0	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{4}{12}$	$\frac{5}{12}$	$\frac{6}{12}$	$\frac{7}{12}$	$\frac{8}{12}$	$\frac{9}{12}$	$\frac{10}{12}$	$\frac{11}{12}$	Diamr.
	Areas												

TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE, THE DIAMETER BEING UNITY.

To find the area of the segment of any circle from the following tables.

RULE.—Divide the height of the segment by the diameter, take out the corresponding tabular area, which multiply by the square of the diameter for the result.

$\frac{H}{D}$	Area	$\frac{H}{D}$	Area	$\frac{H}{D}$	Area	$\frac{H}{D}$	Area
·001	·000042	·038	·009763	·075	·026761	·112	·048262
·002	·000119	·039	·010148	·076	·027289	·113	·048894
·003	·000219	·040	·010537	·077	·027821	·114	·049528
·004	·000337	·041	·010931	·078	·028356	·115	·050165
·005	·000470	·042	·011330	·079	·028894	·116	·050804
·006	·000618	·043	·011734	·080	·029435	·117	·051446
·007	·000779	·044	·012142	·081	·029979	·118	·052090
·008	·000951	·045	·012554	·082	·030526	·119	·052736
·009	·001135	·046	·012971	·083	·031076	·120	·053385
·010	·001329	·047	·013392	·084	·031629	·121	·054036
·011	·001533	·048	·013818	·085	·032186	·122	·054689
·012	·001746	·049	·014247	·086	·032745	·123	·055345
·013	·001968	·050	·014681	·087	·033307	·124	·056003
·014	·002199	·051	·015119	·088	·033872	·125	·056663
·015	·002438	·052	·015561	·089	·034441	·126	·057326
·016	·002685	·053	·016007	·090	·035011	·127	·057991
·017	·002940	·054	·016457	·091	·035585	·128	·058658
·018	·003202	·055	·016911	·092	·036162	·129	·059327
·019	·003471	·056	·017369	·093	·036741	·130	·059999
·020	·003748	·057	·017831	·094	·037323	·131	·060672
·021	·004031	·058	·018296	·095	·037909	·132	·061348
·022	·004322	·059	·018766	·096	·038496	·133	·062026
·023	·004618	·060	·019239	·097	·039087	·134	·062707
·024	·004921	·061	·019716	·098	·039680	·135	·063389
·025	·005230	·062	·020196	·099	·040276	·136	·064074
·026	·005546	·063	·020680	·100	·040875	·137	·064760
·027	·005867	·064	·021168	·101	·041476	·138	·065449
·028	·006194	·065	·021659	·102	·042080	·139	·066140
·029	·006527	·066	·022154	·103	·042687	·140	·066833
·030	·006865	·067	·022652	·104	·043296	·141	·067528
·031	·007209	·068	·023154	·105	·043908	·142	·068225
·032	·007558	·069	·023659	·106	·044522	·143	·068924
·033	·007913	·070	·024168	·107	·045139	·144	·069625
·034	·008273	·071	·024680	·108	·045759	·145	·070328
·035	·008638	·072	·025195	·109	·046381	·146	·071033
·036	·009008	·073	·025714	·110	·047005	·147	·071741
·037	·009383	·074	·026236	·111	·047632	·148	·072450

TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE, THE DIAMETER BEING UNITY (continued).

$\frac{H}{D}$	Area	$\frac{H}{D}$	Area	$\frac{H}{D}$	Area	$\frac{H}{D}$	Area
·149	·073161	·193	·106261	·237	·142387	·281	·180918
·150	·073874	·194	·107051	·238	·143238	·282	·181817
·151	·074589	·195	·107842	·239	·144091	·283	·182718
·152	·075306	·196	·108636	·240	·144944	·284	·183619
·153	·076026	·197	·109430	·241	·145799	·285	·184521
·154	·076747	·198	·110226	·242	·146655	·286	·185425
·155	·077469	·199	·111024	·243	·147512	·287	·186329
·156	·078194	·200	·111823	·244	·148371	·288	·187234
·157	·078921	·201	·112624	·245	·149230	·289	·188140
·158	·079649	·202	·113426	·246	·150091	·290	·189047
·159	·080380	·203	·114230	·247	·150953	·291	·189955
·160	·081112	·204	·115035	·248	·151816	·292	·190864
·161	·081846	·205	·115842	·249	·152680	·293	·191775
·162	·082582	·206	·116650	·250	·153546	·294	·192684
·163	·083320	·207	·117460	·251	·154412	·295	·193596
·164	·084059	·208	·118271	·252	·155280	·296	·194509
·165	·084801	·209	·119083	·253	·156149	·297	·195422
·166	·085544	·210	·119897	·254	·157019	·298	·196337
·167	·086289	·211	·120712	·255	·157890	·299	·197252
·168	·087036	·212	·121529	·256	·158762	·300	·198168
·169	·087785	·213	·122347	·257	·159636	·301	·199085
·170	·088535	·214	·123167	·258	·160510	·302	·200003
·171	·089287	·215	·123988	·259	·161386	·303	·200922
·172	·090041	·216	·124810	·260	·162263	·304	·201841
·173	·090797	·217	·125634	·261	·163140	·305	·202761
·174	·091554	·218	·126459	·262	·164019	·306	·203683
·175	·092313	·219	·127285	·263	·164899	·307	·204605
·176	·093074	·220	·128113	·264	·165780	·308	·205527
·177	·093836	·221	·128942	·265	·166663	·309	·206451
·178	·094601	·222	·129773	·266	·167546	·310	·207376
·179	·095366	·223	·130605	·267	·168430	·311	·208301
·180	·096134	·224	·131438	·268	·169315	·312	·209227
·181	·096903	·225	·132272	·269	·170202	·313	·210154
·182	·097674	·226	·133108	·270	·171089	·314	·211082
·183	·098447	·227	·133945	·271	·171978	·315	·212011
·184	·099221	·228	·134784	·272	·172867	·316	·212940
·185	·099997	·229	·135624	·273	·173758	·317	·213871
·186	·100774	·230	·136465	·274	·174649	·318	·214802
·187	·101553	·231	·137307	·275	·175542	·319	·215733
·188	·102334	·232	·138150	·276	·176435	·320	·216666
·189	·103116	·233	·138995	·277	·177330	·321	·217599
·190	·103900	·234	·139841	·278	·178225	·322	·218533
·191	·104685	·235	·140688	·279	·179122	·323	·219468
·192	·105472	·236	·141537	·280	·180019	·324	·220404

TABLE OF THE AREAS OF THE SEGMENTS OF A CIRCLE, THE DIAMETER BEING UNITY (concluded).

H/D	Area	H/D	Area	H/D	Area	H/D	Area
·325	·221340	·369	·263213	·413	·306140	·457	·349752
·326	·222277	·370	·264178	·414	·307125	·458	·350748
·327	·223215	·371	·265144	·415	·308110	·459	·351745
·328	·224154	·372	·266111	·416	·309095	·460	·352742
·329	·225093	·373	·267078	·417	·310081	·461	·353739
·330	·226033	·374	·268045	·418	·311068	·462	·354736
·331	·226974	·375	·269013	·419	·312054	·463	·355732
·332	·227915	·376	·269982	·420	·313041	·464	·356730
·333	·228858	·377	·270951	·421	·314029	·465	·357727
·334	·229801	·378	·271920	·422	·315016	·466	·358725
·335	·230745	·379	·272890	·423	·316004	·467	·359723
·336	·231689	·380	·273861	·424	·316992	·468	·360721
·337	·232634	·381	·274832	·425	·317981	·469	·361719
·338	·233580	·382	·275803	·426	·318970	·470	·362717
·339	·234526	·383	·276775	·427	·319959	·471	·363715
·340	·235473	·384	·277748	·428	·320948	·472	·364713
·341	·236421	·385	·278721	·429	·321938	·473	·365712
·342	·237369	·386	·279694	·430	·322928	·474	·366710
·343	·238318	·387	·280668	·431	·323918	·475	·367709
·344	·239268	·388	·281642	·432	·324909	·476	·368708
·345	·240218	·389	·282617	·433	·325900	·477	·369707
·346	·241169	·390	·283592	·434	·326892	·478	·370706
·347	·242121	·391	·284568	·435	·327882	·479	·371705
·348	·243074	·392	·285544	·436	·328874	·480	·372704
·349	·244026	·393	·286521	·437	·329866	·481	·373703
·350	·244980	·394	·287498	·438	·330858	·482	·374702
·351	·245934	·395	·288476	·439	·331850	·483	·375702
·352	·246889	·396	·289453	·440	·332843	·484	·376702
·353	·247845	·397	·290432	·441	·333836	·485	·377701
·354	·248801	·398	·291411	·442	·334829	·486	·378701
·355	·249757	·399	·292390	·443	·335822	·487	·379700
·356	·250715	·400	·293369	·444	·336816	·488	·380700
·357	·251673	·401	·294349	·445	·337810	·489	·381699
·358	·252631	·402	·295330	·446	·338804	·490	·382699
·359	·253590	·403	·296311	·447	·339798	·491	·383699
·360	·254550	·404	·297292	·448	·340793	·492	·384699
·361	·255510	·405	·298273	·449	·341787	·493	·385699
·362	·256471	·406	·299255	·450	·342782	·494	·386699
·363	·257433	·407	·300238	·451	·343777	·495	·387699
·364	·258395	·408	·301220	·452	·344772	·496	·388699
·365	·259357	·409	·302203	·453	·345768	·497	·389699
·366	·260320	·410	·303187	·454	·346764	·498	·390699
·367	·261284	·411	·304171	·455	·347759	·499	·391699
·368	·262248	·412	·305155	·456	·348755	·500	·392699

TABLE OF SQUARES, CUBES, SQUARE ROOTS, CUBE ROOTS, AN RECIPROCALS OF ALL INTEGER NUMBERS FROM 1 TO 2200

No.	Square	Cube	Square Root	Cube Root	Reciproca
1	1	1	1·0000000	1·0000000	1·00000000
2	4	8	1·4142136	1·2599210	·50000000
3	9	27	1·7320508	1·4422496	·33333333
4	16	64	2·0000000	1·5874011	·25000000
5	25	125	2·2360680	1·7099759	·20000000
6	36	216	2·4494897	1·8171206	·16666666
7	49	343	2·6457513	1·9129312	·14285714
8	64	512	2·8284271	2·0000000	·12500000
9	81	729	3·0000000	2·0800837	·11111111
10	100	1000	3·1622777	2·1544347	·10000000
11	121	1331	3·3166248	2·2239801	·09090909
12	144	1728	3·4641016	2·2894286	·08333333
13	169	2197	3·6055513	2·3513347	·07692307
14	196	2744	3·7416574	2·4101422	·07142857
15	225	3375	3·8729833	2·4662121	·06666666
16	256	4096	4·0000000	2·5198421	·06250000
17	289	4913	4·1231056	2·5712816	·05882352
18	324	5832	4·2426407	2·6207414	·05555555
19	361	6859	4·3588989	2·6684016	·05263157
20	400	8000	4·4721360	2·7144177	·05000000
21	441	9261	4·5825757	2·7589243	·04761904
22	484	10648	4·6904158	2·8020393	·04545454
23	529	12167	4·7958315	2·8438670	·04347826
24	576	13824	4·8989795	2·8844991	·04166666
25	625	15625	5·0000000	2·9240177	·04000000
26	676	17576	5·0990195	2·9624960	·03846153
27	729	19683	5·1961524	3·0000000	·03703703
28	784	21952	5·2915026	3·0365889	·03571428
29	841	24389	5·3851648	3·0723168	·03448275
30	900	27000	5·4772256	3·1072325	·03333333
31	961	29791	5·5677644	3·1413806	·03225806
32	1024	32768	5·6568542	3·1748021	·03125000
33	1089	35937	5·7445626	3·2075343	·03030303
34	1156	39304	5·8309519	3·2396118	·02941176
35	1225	42875	5·9160798	3·2710663	·02857142
36	1296	46656	6·0000000	3·3019272	·02777777
37	1369	50653	6·0827625	3·3322218	·02702702
38	1444	54872	6·1644140	3·3619754	·02631578
39	1521	59319	6·2449980	3·3912114	·02564102
40	1600	64000	6·3245553	3·4199519	·02500000
41	1681	68921	6·4031242	3·4482172	·02439024
42	1764	74088	6·4807407	3·4760266	·02380952
43	1849	79507	6·5574385	3·5033981	·02325581
44	1936	85184	6·6332496	3·5303483	·02272727
45	2025	91125	6·7082039	3·5568933	·02222222

No.	Square	Cube	Square Root	Cube Root	Reciprocal
46	2116	97336	6·7823300	3·5830479	·021739130
47	2209	103823	6·8556546	3·6088261	·021276600
48	2304	110592	6·9282032	3·6342411	·020833333
49	2401	117649	7·0000000	3·6593057	·020408163
50	2500	125000	7·0710678	3·6840314	·020000000
51	2601	132651	7·1414284	3·7084298	·019607843
52	2704	140608	7·2111026	3·7325111	·019230769
53	2809	148877	7·2801099	3·7562858	·018867925
54	2916	157464	7·3484692	3·7797631	·018518519
55	3025	166375	7·4161985	3·8029525	·018181818
56	3136	175616	7·4833148	3·8258624	·017857143
57	3249	185193	7·5498344	3·8485011	·017543860
58	3364	195112	7·6157731	3·8708766	·017241379
59	3481	205379	7·6811457	3·8929965	·016949153
60	3600	216000	7·7459667	3·9148676	·016666667
61	3721	226981	7·8102497	3·9364972	·016393443
62	3844	238328	7·8740079	3·9578915	·016129032
63	3969	250047	7·9372539	3·9790571	·015873016
64	4096	262144	8·0000000	4·0000000	·015625000
65	4225	274625	8·0622577	4·0207256	·015384615
66	4356	287496	8·1240384	4·0412401	·015151515
67	4489	300763	8·1853528	4·0615480	·014925373
68	4624	314432	8·2462113	4·0816551	·014705882
69	4761	328509	8·3066239	4·1015661	·014492754
70	4900	343000	8·3666003	4·1212853	·014285714
71	5041	357911	8·4261498	4·1408178	·014084507
72	5184	373248	8·4852814	4·1601676	·013888889
73	5329	389017	8·5440037	4·1793392	·013698630
74	5476	405224	8·6023253	4·1983364	·013513514
75	5625	421875	8·6602540	4·2171633	·013333333
76	5776	438976	8·7177979	4·2358236	·013157895
77	5929	456533	8·7749644	4·2543210	·012987013
78	6084	474552	8·8317609	4·2726586	·012820513
79	6241	493039	8·8881944	4·2908404	·012658228
80	6400	512000	8·9442719	4·3088695	·012500000
81	6561	531441	9·0000000	4·3267487	·012345679
82	6724	551368	9·0553851	4·3444815	·012195122
83	6889	571787	9·1104336	4·3620707	·012048193
84	7056	592704	9·1651514	4·3795191	·011904762
85	7225	614125	9·2195445	4·3968296	·011764706
86	7396	636056	9·2736185	4·4140049	·011627907
87	7569	658503	9·3273791	4·4310476	·011494253
88	7744	681472	9·3808315	4·4479602	·011363636
89	7921	704969	9·4339811	4·4647451	·011235955
90	8100	729000	9·4868330	4·4814047	·011111111
91	8281	753571	9·5393920	4·4979414	·010989011
92	8464	778688	9·5916630	4·5143574	·010869565
93	8649	804357	9·6436508	4·5306549	·010752688
94	8836	830584	9·6953597	4·5468359	·010638298

No.	Square	Cube	Square Root	Cube Root	Reciprocal
95	9025	857375	9·7467943	4·5629026	·010526316
96	9216	884736	9·7979590	4·5788570	·010416667
97	9409	912673	9·8488578	4·5947009	·010309278
98	9604	941192	9·8994949	4·6104363	·010204082
99	9801	970299	9·9498744	4·6260650	·010101010
100	10000	1000000	10·0000000	4·6415888	·010000000
101	10201	1030301	10·0498756	4·6570095	·009900990
102	10404	1061208	10·0995049	4·6723287	·009803922
103	10609	1092727	10·1488916	4·6875482	·009708738
104	10816	1124864	10·1980390	4·7026694	·009615385
105	11025	1157625	10·2469508	4·7176940	·009523810
106	11236	1191016	10·2956301	4·7326235	·009433962
107	11449	1225043	10·3440804	4·7474594	·009345794
108	11664	1259712	10·3923048	4·7622032	·009259259
109	11881	1295029	10·4403065	4·7768562	·009174312
110	12100	1331000	10·4880885	4·7914199	·009090909
111	12321	1367631	10·5356538	4·8058955	·009009009
112	12544	1404928	10·5830052	4·8202845	·008928571
113	12769	1442897	10·6301458	4·8345881	·008849558
114	12996	1481544	10·6770783	4·8488076	·008771930
115	13225	1520875	10·7238053	4·8629442	·008695652
116	13456	1560896	10·7703296	4·8769990	·008620690
117	13689	1601613	10·8166538	4·8909732	·008547009
118	13924	1643032	10·8627805	4·9048681	·008474576
119	14161	1685159	10·9087121	4·9186847	·008403361
120	14400	1728000	10·9544512	4·9324242	·008333333
121	14641	1771561	11·0000000	4·9460874	·008264463
122	14884	1815848	11·0453610	4·9596757	·008196721
123	15129	1860867	11·0905365	4·9731898	·008130081
124	15376	1906624	11·1355287	4·9866310	·008064516
125	15625	1953125	11·1803399	5·0000000	·008000000
126	15876	2000376	11·2249722	5·0132979	·007936508
127	16129	2048383	11·2694277	5·0265257	·007874016
128	16384	2097152	11·3137085	5·0396842	·007812500
129	16641	2146689	11·3578167	5·0527743	·007751938
130	16900	2197000	11·4017543	5·0657970	·007692308
131	17161	2248091	11·4455231	5·0787531	·007633588
132	17424	2299968	11·4891253	5·0916434	·007575758
133	17689	2352637	11·5325626	5·1044687	·007518797
134	17956	2406104	11·5758369	5·1172299	·007462687
135	18225	2460375	11·6189500	5·1299278	·007407407
136	18496	2515456	11·6619038	5·1425632	·007352941
137	18769	2571353	11·7046999	5·1551367	·007299270
138	19044	2628072	11·7473401	5·1676498	·007246377
139	19321	2685619	11·7898261	5·1801015	·007194245
140	19600	2744000	11·8321596	5·1924941	·007142857
141	19881	2803221	11·8743422	5·2048279	·007092199
142	20164	2863288	11·9163753	5·2171034	·007042254
143	20449	2924207	11·9582607	5·2293215	·006993007

No.	Square	Cube	Square Root	Cube Root	Reciprocal
144	20736	2985984	12·0000000	5·2414828	·006944444
145	21025	3048625	12·0415946	5·2535879	·006896552
146	21316	3112136	12·0830460	5·2656374	·006849315
147	21609	3176523	12·1243557	5·2776321	·006802721
148	21904	3241792	12·1655251	5·2895725	·006756757
149	22201	3307949	12·2065556	5·3014592	·006711409
150	22500	3375000	12·2474487	5·3132928	·006666667
151	22801	3442951	12·2882057	5·3250740	·006622517
152	23104	3511808	12·3288280	5·3368033	·006578947
153	23409	3581577	12·3693169	5·3484812	·006535948
154	23716	3652264	12·4096736	5·3601084	·006493506
155	24025	3723875	12·4498996	5·3716854	·006451613
156	24336	3796416	12·4899960	5·3832126	·006410256
157	24649	3869893	12·5299641	5·3946907	·006369427
158	24964	3944312	12·5698051	5·4061202	·006329114
159	25281	4019679	12·6095202	5·4175015	·006289308
160	25600	4096000	12·6491106	5·4288352	·006250000
161	25921	4173281	12·6885775	5·4401218	·006211180
162	26244	4251528	12·7279221	5·4513618	·006172840
163	26569	4330747	12·7671453	5·4625556	·006134969
164	26896	4410944	12·8062485	5·4737037	·006097561
165	27225	4492125	12·8452326	5·4848066	·006060606
166	27556	4574296	12·8840987	5·4958647	·006024096
167	27889	4657463	12·9228480	5·5068784	·005988024
168	28224	4741632	12·9614814	5·5178484	·005952381
169	28561	4826809	13·0000000	5·5287748	·005917160
170	28900	4913000	13·0384048	5·5396583	·005882353
171	29241	5000211	13·0766968	5·5504991	·005847953
172	29584	5088448	13·1148770	5·5612978	·005813953
173	29929	5177717	13·1529464	5·5720546	·005780347
174	30276	5268024	13·1909060	5·5827702	·005747126
175	30625	5359375	13·2287566	5·5934447	·005714286
176	30976	5451776	13·2664992	5·6040787	·005681818
177	31329	5545233	13·3041347	5·6146724	·005649718
178	31684	5639752	13·3416641	5·6252263	·005617978
179	32041	5735339	13·3790882	5·6357408	·005586592
180	32400	5832000	13·4164079	5·6462162	·005555556
181	32761	5929741	13·4536240	5·6566528	·005524862
182	33124	6028568	13·4907376	5·6670511	·005494505
183	33489	6128487	13·5277493	5·6774114	·005464481
184	33856	6229504	13·5646600	5·6877340	·005434783
185	34225	6331625	13·6014705	5·6980192	·005405405
186	34596	6434856	13·6381817	5·7082675	·005376344
187	34969	6539203	13·6747943	5·7184791	·005347594
188	35344	6644672	13·7113092	5·7286543	·005319149
189	35721	6751269	13·7477271	5·7387936	·005291005
190	36100	6859000	13·7840488	5·7488971	·005263158
191	36481	6967871	13·8202750	5·7589652	·005235602
192	36864	7077888	13·8564065	5·7689982	·005208333

No.	Square	Cube	Square Root	Cube Root	Reciprocal
193	37249	7189057	13·8924440	5·7789966	·005181347
194	37636	7301384	13·9283888	5·7889604	·005154639
195	38025	7414875	13·9642400	5·7988900	·005128205
196	38416	7529536	14·0000000	5·8087857	·005102041
197	38809	7645373	14·0356688	5·8186479	·005076142
198	39204	7762392	14·0712473	5·8284767	·005050505
199	39601	7880599	14·1067360	5·8382725	·005025126
200	40000	8000000	14·1421356	5·8480355	·005000000
201	40401	8120601	14·1774469	5·8577660	·004975124
202	40804	8242408	14·2126704	5·8674643	·004950495
203	41209	8365427	14·2478068	5·8771307	·004926108
204	41616	8489664	14·2828569	5·8867653	·004901961
205	42025	8615125	14·3178211	5·8963685	·004878049
206	42436	8741816	14·3527001	5·9059406	·004854369
207	42849	8869743	14·3874946	5·9154817	·004830918
208	43264	8998912	14·4222051	5·9249921	·004807692
209	43681	9129329	14·4568323	5·9344721	·004784689
210	44100	9261000	14·4913767	5·9439220	·004761905
211	44521	9393931	14·5258390	5·9533418	·004739336
212	44944	9528128	14·5602198	5·9627320	·004716981
213	45369	9663597	14·5945195	5·9720926	·004694836
214	45796	9800344	14·6287388	5·9814240	·004672897
215	46225	9938375	14·6628783	5·9907264	·004651163
216	46656	10077696	14·6969385	6·0000000	·004629630
217	47089	10218313	14·7309199	6·0092450	·004608295
218	47524	10360232	14·7648231	6·0184617	·004587156
219	47961	10503459	14·7986486	6·0276502	·004566210
220	48400	10648000	14·8323970	6·0368107	·004545455
221	48841	10793861	14·8660687	6·0459435	·004524887
222	49284	10941048	14·8996644	6·0550489	·004504505
223	49729	11089567	14·9331845	6·0641270	·004484305
224	50176	11239424	14·9666295	6·0731779	·004464286
225	50625	11390625	15·0000000	6·0822020	·004444444
226	51076	11543176	15·0332964	6·0911994	·004424779
227	51529	11697083	15·0665192	6·1001702	·004405286
228	51984	11852352	15·0996689	6·1091147	·004385965
229	52441	12008989	15·1327460	6·1180332	·004366812
230	52900	12167000	15·1657509	6·1269257	·004347826
231	53361	12326391	15·1986842	6·1357924	·004329004
232	53824	12487168	15·2315462	6·1446337	·004310345
233	54289	12649337	15·2643375	6·1534495	·004291845
234	54756	12812904	15·2970585	6·1622401	·004273504
235	55225	12977875	15·3297097	6·1710058	·004255319
236	55696	13144256	15·3622915	6·1797466	·004237288
237	56169	13312053	15·3948043	6·1884628	·004219409
238	56644	13481272	15·4272486	6·1971544	·004201681
239	57121	13651919	15·4596248	6·2058218	·004184100
240	57600	13824000	15·4919334	6·2144650	·004166667
241	58081	13997521	15·5241747	6·2230843	·004149378

No.	Square	Cube	Square Root	Cube Root	Reciprocal
242	58564	14172488	15·5563492	6·2316797	·004132231
243	59049	14348907	15·5884573	6·2402515	·004115226
244	59536	14526784	15·6204994	6·2487998	·004098361
245	60025	14706125	15·6524758	6·2573248	·004081633
246	60516	14886936	15·6843871	6·2658266	·004065041
247	61009	15069223	15·7162336	6·2743054	·004048583
248	61504	15252992	15·7480157	6·2827613	·004032258
249	62001	15438249	15·7797338	6·2911946	·004016064
250	62500	15625000	15·8113883	6·2996053	·004000000
251	63001	15813251	15·8429795	6·3079935	·003984064
252	63504	16003008	15·8745079	6·3163596	·003968254
253	64009	16194277	15·9059737	6·3247035	·003952569
254	64516	16387064	15·9373775	6·3330256	·003937008
255	65025	16581375	15·9687194	6·3413257	·003921569
256	65536	16777216	16·0000000	6·3496042	·003906250
257	66049	16974593	16·0312195	6·3578611	·003891051
258	66564	17173512	16·0623784	6·3660968	·003875969
259	67081	17373979	16·0934769	6·3743111	·003861004
260	67600	17576000	16·1245155	6·3825043	·003846154
261	68121	17779581	16·1554944	6·3906765	·003831418
262	68644	17984728	16·1864141	6·3988279	·003816794
263	69169	18191447	16·2172747	6·4069585	·003802281
264	69696	18399744	16·2480768	6·4150687	·003787879
265	70225	18609625	16·2788206	6·4231583	·003773585
266	70756	18821096	16·3095064	6·4312276	·003759398
267	71289	19034163	16·3401346	6·4392767	·003745318
268	71824	19248832	16·3707055	6·4473057	·003731343
269	72361	19465109	16·4012195	6·4553148	·003717472
270	72900	19683000	16·4316767	6·4633041	·003703704
271	73441	19902511	16·4620776	6·4712736	·003690037
272	73984	20123648	16·4924225	6·4792236	·003676471
273	74529	20346417	16·5227116	6·4871541	·003663004
274	75076	20570824	16·5529454	6·4950653	·003649635
275	75625	20796875	16·5831240	6·5029572	·003636364
276	76176	21024576	16·6132477	6·5108300	·003623188
277	76729	21253933	16·6433170	6·5186839	·003610108
278	77284	21484952	16·6733320	6·5265189	·003597122
279	77841	21717639	16·7032931	6·5343351	·003584229
280	78400	21952000	16·7332005	6·5421326	·003571429
281	78961	22188041	16·7630546	6·5499116	·003558719
282	79524	22425768	16·7928556	6·5576722	·003546099
283	80089	22665187	16·8226038	6·5654144	·003533569
284	80656	22906304	16·8522995	6·5731385	·003521127
285	81225	23149125	16·8819430	6·5808443	·003508772
286	81796	23393656	16·9115345	6·5885323	·003496503
287	82369	23639903	16·9410743	6·5962023	·003484321
288	82944	23887872	16·9705627	6·6038545	·003472222
289	83521	24137569	17·0000000	6·6114890	·003460208
290	84100	24389000	17·0293864	6·6191060	·003448276

No.	Square	Cube	Square Root	Cube Root	Reciprocal
291	84681	24642171	17·0587221	6·6267054	·003436426
292	85264	24897088	17·0880075	6·6342874	·003424658
293	85849	25153757	17·1172428	6·6418522	·003412969
294	86436	25412184	17·1464282	6·6493998	·003401361
295	87025	25672375	17·1755640	6·6569302	·003389831
296	87616	25934336	17·2046505	6·6644437	·003378378
297	88209	26198073	17·2336879	6·6719403	·003367003
298	88804	26463592	17·2626765	6·6794200	·003355705
299	89401	26730899	17·2916165	6·6868831	·003344482
300	90000	27000000	17·3205081	6·6943295	·003333333
301	90601	27270901	17·3493516	6·7017593	·003322259
302	91204	27543608	17·3781472	6·7091729	·003311258
303	91809	27818127	17·4068952	6·7165700	·003300330
304	92416	28094464	17·4355958	6·7239508	·003289474
305	93025	28372625	17·4642492	6·7313155	·003278689
306	93636	28652616	17·4928557	6·7386641	·003267974
307	94249	28934443	17·5214155	6·7459967	·003257329
308	94864	29218112	17·5499288	6·7533134	·003246753
309	95481	29503629	17·5783958	6·7606143	·003236246
310	96100	29791000	17·6068169	6·7678995	·003225806
311	96721	30080231	17·6351921	6·7751690	·003215434
312	97344	30371328	17·6635217	6·7824229	·003205128
313	97969	30664297	17·6918060	6·7896613	·003194888
314	98596	30959144	17·7200451	6·7968844	·003184713
315	99225	31255875	17·7482393	6·8040921	·003174603
316	99856	31554496	17·7763888	6·8112847	·003164557
317	100489	31855013	17·8044938	6·8184620	·003154574
318	101124	32157432	17·8325545	6·8256242	·003144654
319	101761	32461759	17·8605711	6·8327714	·003134796
320	102400	32768000	17·8885438	6·8399037	·003125000
321	103041	33076161	17·9164729	6·8470213	·003115265
322	103684	33386248	17·9443584	6·8541240	·003105590
323	104329	33698267	17·9722008	6·8612120	·003095975
324	104976	34012224	18·0000000	6·8682855	·003086420
325	105625	34328125	18·0277564	6·8753443	·003076923
326	106276	34645976	18·0554701	6·8823888	·003067485
327	106929	34965783	18·0831413	6·8894188	·003058104
328	107584	35287552	18·1107703	6·8964345	·003048780
329	108241	35611289	18·1383571	6·9034359	·003039514
330	108900	35937000	18·1659021	6·9104232	·003030303
331	109561	36264691	18·1934054	6·9173964	·003021148
332	110224	36594368	18·2208672	6·9243556	·003012048
333	110889	36926037	18·2482876	6·9313008	·003003003
334	111556	37259704	18·2756669	6·9382321	·002994012
335	112225	37595375	18·3030052	6·9451496	·002985075
336	112896	37933056	18·3303028	6·9520533	·002976190
337	113569	38272753	18·3575598	6·9589434	·002967359
338	114244	38614472	18·3847763	6·9658198	·002958580
339	114921	38958219	18·4119526	6·9726826	·002949853

No.	Square	Cube	Square Root	Cube Root	Reciprocal
340	115600	39304000	18·4390889	6·9795321	·002941176
341	116281	39651821	18·4661853	6·9863681	·002932551
342	116964	40001688	18·4932420	6·9931906	·002923977
343	117649	40353607	18·5202592	7·0000000	·002915452
344	118336	40707584	18·5472370	7·0067962	·002906977
345	119025	41063625	18·5741756	7·0135791	·002898551
346	119716	41421736	18·6010752	7·0203490	·002890173
347	120409	41781923	18·6279360	7·0271058	·002881844
348	121104	42144192	18·6547581	7·0338497	·002873563
349	121801	42508549	18·6815147	7·0405806	·002865330
350	122500	42875000	18·7082869	7·0472987	·002857143
351	123201	43243551	18·7349940	7·0540041	·002849003
352	123904	43614208	18·7616630	7·0606967	·002840909
353	124609	43986977	18·7882942	7·0673767	·002832861
354	125316	44361864	18·8148877	7·0740440	·002824859
355	126025	44738875	18·8414437	7·0806988	·002816901
356	126736	45118016	18·8679623	7·0873411	·002808989
357	127449	45499293	18·8944436	7·0939709	·002801120
358	128164	45882712	18·9208879	7·1005885	·002793296
359	128881	46268279	18·9472953	7·1071937	·002785515
360	129600	46656000	18·9736660	7·1137866	·002777778
361	130321	47045881	19·0000000	7·1203674	·002770083
362	131044	47437928	19·0262976	7·1269360	·002762431
363	131769	47832147	19·0525589	7·1334925	·002754821
364	132496	48228544	19·0787840	7·1400370	·002747253
365	133225	48627125	19·1049732	7·1465695	·002739726
366	133956	49027896	19·1311265	7·1530901	·002732240
367	134689	49430863	19·1572441	7·1595988	·002724796
368	135424	49836032	19·1833261	7·1660957	·002717391
369	136161	50243409	19·2093727	7·1725809	·002710027
370	136900	50653000	19·2353841	7·1790544	·002702703
371	137641	51064811	19·2613603	7·1855162	·002695418
372	138384	51478848	19·2873015	7·1919663	·002688172
373	139129	51895117	19·3132079	7·1984050	·002680965
374	139876	52313624	19·3390796	7·2048322	·002673797
375	140625	52734375	19·3649167	7·2112479	·002666667
376	141376	53157376	19·3907194	7·2176522	·002659574
377	142129	53582633	19·4164878	7·2240450	·002652520
378	142884	54010152	19·4422221	7·2304268	·002645503
379	143641	54439939	19·4679223	7·2367972	·002638522
380	144400	54872000	19·4935887	7·2431565	·002631579
381	145161	55306341	19·5192213	7·2495045	·002624672
382	145924	55742968	19·5448203	7·2558415	·002617801
383	146689	56181887	19·5703858	7·2621675	·002610966
384	147456	56623104	19·5959179	7·2684824	·002604167
385	148225	57066625	19·6214169	7·2747864	·002597403
386	148996	57512456	19·6468827	7·2810794	·002590674
387	149769	57960603	19·6723156	7·2873617	·002583979
388	150544	58411072	19·6977156	7·2936330	·002577320

No.	Square	Cube	Square Root	Cube Root	Reciprocal
389	151321	58863869	19·7230829	7·2998936	·002570694
390	152100	59319000	19·7484177	7·3061436	·002564103
391	152881	59776471	19·7737199	7·3123828	·002557545
392	153664	60236288	19·7989899	7·3186114	·002551020
393	154449	60698457	19·8242276	7·3248295	·002544529
394	155236	61162984	19·8494332	7·3310369	·002538071
395	156025	61629875	19·8746069	7·3372339	·002531646
396	156816	62099136	19·8997487	7·3434205	·002525253
397	157609	62570773	19·9248588	7·3495966	·002518892
398	158404	63044792	19·9499373	7·3557624	·002512563
399	159201	63521199	19·9749844	7·3619178	·002506266
400	160000	64000000	20·0000000	7·3680630	·002500000
401	160801	64481201	20·0249844	7·3741979	·002493766
402	161604	64964808	20·0499377	7·3803227	·002487562
403	162409	65450827	20·0748599	7·3864373	·002481390
404	163216	65939264	20·0997512	7·3925418	·002475248
405	164025	66430125	20·1246118	7·3986363	·002469136
406	164836	66923416	20·1494417	7·4047206	·002463054
407	165649	67419143	20·1742410	7·4107950	·002457002
408	166464	67917312	20·1990099	7·4168595	·002450980
409	167281	68417929	20·2237484	7·4229142	·002444988
410	168100	68921000	20·2484567	7·4289589	·002439024
411	168921	69426531	20·2731349	7·4349938	·002433090
412	169744	69934528	20·2977831	7·4410189	·002427184
413	170569	70444997	20·3224014	7·4470342	·002421308
414	171396	70957944	20·3469899	7·4530399	·002415459
415	172225	71473375	20·3715488	7·4590359	·002409639
416	173056	71991296	20·3960781	7·4650223	·002403846
417	173889	72511713	20·4205779	7·4709991	·002398082
418	174724	73034632	20·4450483	7·4769664	·002392344
419	175561	73560059	20·4694895	7·4829242	·002386635
420	176400	74088000	20·4939015	7·4888724	·002380952
421	177241	74618461	20·5182845	7·4948113	·002375297
422	178084	75151448	20·5426386	7·5007406	·002369668
423	178929	75686967	20·5669638	7·5066607	·002364066
424	179776	76225024	20·5912603	7·5125715	·002358491
425	180625	76765625	20·6155281	7·5184730	·002352941
426	181476	77308776	20·6397674	7·5243652	·002347418
427	182329	77854483	20·6639783	7·5302482	·002341920
428	183184	78402752	20·6881609	7·5361221	·002336449
429	184041	78953589	20·7123152	7·5419867	·002331002
430	184900	79507000	20·7364414	7·5478423	·002325581
431	185761	80062991	20·7605395	7·5536888	·002320186
432	186624	80621568	20·7846097	7·5595263	·002314815
433	187489	81182737	20·8086520	7·5653548	·002309469
434	188356	81746504	20·8326667	7·5711743	·002304147
435	189225	82312875	20·8566536	7·5769849	·002298851
436	190096	82881856	20·8806130	7·5827865	·002293578
437	190969	83453453	20·9045450	7·5885793	·002288330

No.	Square	Cube	Square Root	Cube Root	Reciprocal
438	191844	84027672	20·9284495	7·5943633	·002283105
439	192721	84604519	20·9523268	7·6001385	·002277004
440	193600	85184000	20·9761770	7·6059049	·002272727
441	194481	85766121	21·0000000	7·6116626	·002267574
442	195364	86350888	21·0237960	7·6174116	·002262443
443	196249	86938307	21·0475652	7·6231519	·002257336
444	197136	87528384	21·0713075	7·6288837	·002252252
445	198025	88121125	21·0950231	7·6346067	·002247191
446	198916	88716536	21·1187121	7·6403213	·002242152
447	199809	89314623	21·1423745	7·6460272	·002237136
448	200704	89915392	21·1660105	7·6517247	·002232143
449	201601	90518849	21·1896201	7·6574138	·002227171
450	202500	91125000	21·2132034	7·6630943	·002222222
451	203401	91733851	21·2367606	7·6687665	·002217295
452	204304	92345408	21·2602916	7·6744303	·002212389
453	205209	92959677	21·2837967	7·6800857	·002207506
454	206116	93576664	21·3072758	7·6857328	·002202643
455	207025	94196375	21·3307290	7·6913717	·002197802
456	207936	94818816	21·3541565	7·6970023	·002192982
457	208849	95443993	21·3775583	7·7026246	·002188184
458	209764	96071912	21·4009346	7·7082388	·002183406
459	210681	96702579	21·4242853	7·7138448	·002178649
460	211600	97336000	21·4476106	7·7194426	·002173913
461	212521	97972181	21·4709106	7·7250325	·002169197
462	213444	98611128	21·4941853	7·7306141	·002164502
463	214369	99252847	21·5174348	7·7361877	·002159827
464	215296	99897344	21·5406592	7·7417532	·002155172
465	216225	100544625	21·5638587	7·7473109	·002150538
466	217156	101194696	21·5870331	7·7528606	·002145923
467	218089	101847563	21·6101828	7·7584023	·002141328
468	219024	102503232	21·6333077	7·7639361	·002136752
469	219961	103161709	21·6564078	7·7694620	·002132196
470	220900	103823000	21·6794834	7·7749801	·002127660
471	221841	104487111	21·7025344	7·7804904	·002123142
472	222784	105154048	21·7255610	7·7859928	·002118644
473	223729	105823817	21·7485632	7·7914875	·002114165
474	224676	106496424	21·7715411	7·7969745	·002109705
475	225625	107171875	21·7944947	7·8024538	·002105263
476	226576	107850176	21·8174242	7·8079254	·002100840
477	227529	108531333	21·8403297	7·8133892	·002096436
478	228484	109215352	21·8632111	7·8188456	·002092050
479	229441	109902239	21·8860686	7·8242942	·002087683
480	230400	110592000	21·9089023	7·8297353	·002083333
481	231361	111284641	21·9317122	7·8351688	·002079002
482	232324	111980168	21·9544984	7·8405949	·002074689
483	233289	112678587	21·9772610	7·8460134	·002070393
484	234256	113379904	22·0000000	7·8514244	·002066116
485	235225	114084125	22·0227155	7·8568281	·002061856
486	236196	114791256	22·0454077	7·8622242	·002057613

No.	Square	Cube	Square Root	Cube Root	Reciprocal
487	237169	115501303	22·0680765	7·8676130	·002053388
488	238144	116214272	22·0907220	7·8729944	·002049180
489	239121	116930169	22·1133444	7·8783684	·002044990
490	240100	117649000	22·1359436	7·8837352	·002040816
491	241081	118370771	22·1585198	7·8890946	·002036660
492	242064	119095488	22·1810730	7·8944468	·002032520
493	243049	119823157	22·2036033	7·8997917	·002028398
494	244036	120553784	22·2261108	7·9051294	·002024291
495	245025	121287375	22·2485955	7·9104599	·002020202
496	246016	122023936	22·2710575	7·9157832	·002016129
497	247009	122763473	22·2934968	7·9210994	·002012072
498	248004	123505992	22·3159136	7·9264085	·002008032
499	249001	124251499	22·3383079	7·9317104	·002004008
500	250000	125000000	22·3606798	7·9370053	·002000000
501	251001	125751501	22·3830293	7·9422931	·001996008
502	252004	126506008	22·4053565	7·9475739	·001992032
503	253009	127263527	22·4276615	7·9528477	·001988072
504	254016	128024064	22·4499443	7·9581144	·001984127
505	255025	128787625	22·4722051	7·9633743	·001980198
506	256036	129554216	22·4944438	7·9686271	·001976285
507	257049	130323843	22·5166605	7·9738731	·001972387
508	258064	131096512	22·5388553	7·9791122	·001968504
509	259081	131872229	22·5610283	7·9843444	·001964637
510	260100	132651000	22·5831796	7·9895697	·001960784
511	261121	133432831	22·6053091	7·9947883	·001956947
512	262144	134217728	22·6274170	8·0000000	·001953125
513	263169	135005697	22·6495033	8·0052049	·001949318
514	264196	135796744	22·6715681	8·0104032	·001945525
515	265225	136590875	22·6936114	8·0155946	·001941748
516	266256	137388096	22·7156334	8·0207794	·001937984
517	267289	138188413	22·7376340	8·0259574	·001934236
518	268324	138991832	22·7596134	8·0311287	·001930502
519	269361	139798359	22·7815715	8·0362935	·001926782
520	270400	140608000	22·8035085	8·0414515	·001923077
521	271441	141420761	22·8254244	8·0466030	·001919386
522	272484	142236648	22·8473193	8·0517479	·001915709
523	273529	143055667	22·8691933	8·0568862	·001912046
524	274576	143877824	22·8910463	8·0620180	·001908397
525	275625	144703125	22·9128785	8·0671432	·001904762
526	276676	145531576	22·9346899	8·0722620	·001901141
527	277729	146363183	22·9564806	8·0773743	·001897533
528	278784	147197952	22·9782506	8·0824800	·001893939
529	279841	148035889	23·0000000	8·0875794	·001890359
530	280900	148877000	23·0217289	8·0926723	·001886792
531	281961	149721291	23·0434372	8·0977589	·001883239
532	283024	150568768	23·0651252	8·1028390	·001879699
533	284089	151419437	23·0867928	8·1079128	·001876173
534	285156	152273304	23·1084400	8·1129803	·001872659
535	286225	153130375	23·1300670	8·1180414	·001869159

No.	Square	Cube	Square Root	Cube Root	Reciprocal
536	287296	153990656	23·1516738	8·1230962	·001865672
537	288369	154854153	23·1732605	8·1281447	·001862197
538	289444	155720872	23·1948270	8·1331870	·001858736
539	290521	156590819	23·2163735	8·1382230	·001855288
540	291600	157464000	23·2379001	8·1432529	·001851852
541	292681	158340421	23·2594067	8·1482765	·001848429
542	293764	159220088	23·2808935	8·1532939	·001845018
543	294849	160103007	23·3023604	8·1583051	·001841621
544	295936	160989184	23·3238076	8·1633102	·001838235
545	297025	161878625	23·3452351	8·1683092	·001834862
546	298116	162771336	23·3666429	8·1733020	·001831502
547	299209	163667323	23·3880311	8·1782888	·001828154
548	300304	164566592	23·4093998	8·1832695	·001824818
549	301401	165469149	23·4307490	8·1882441	·001821494
550	302500	166375000	23·4520788	8·1932127	·001818182
551	303601	167284151	23·4733892	8·1981753	·001814882
552	304704	168196608	23·4946802	8·2031319	·001811594
553	305809	169112377	23·5159520	8·2080825	·001808318
554	306916	170031464	23·5372046	8·2130271	·001805054
555	308025	170953875	23·5584380	8·2179657	·001801802
556	309136	171879616	23·5796522	8·2228985	·001798561
557	310249	172808693	23·6008474	8·2278254	·001795332
558	311364	173741112	23·6220236	8·2327463	·001792115
559	312481	174676879	23·6431808	8·2376614	·001788909
560	313600	175616000	23·6643191	8·2425706	·001785714
561	314721	176558481	23·6854386	8·2474740	·001782531
562	315844	177504328	23·7065392	8·2523715	·001779359
563	316969	178453547	23·7276210	8·2572633	·001776199
564	318096	179406144	23·7486842	8·2621492	·001773050
565	319225	180362125	23·7697286	8·2670294	·001769912
566	320356	181321496	23·7907545	8·2719039	·001766784
567	321489	182284263	23·8117618	8·2767726	·001763668
568	322624	183250432	23·8327506	8·2816355	·001760563
569	323761	184220009	23·8537209	8·2864928	·001757469
570	324900	185193000	23·8746728	8·2913444	·001754386
571	326041	186169411	23·8956063	8·2961903	·001751313
572	327184	187149248	23·9165215	8·3010304	·001748252
573	328329	188132517	23·9374184	8·3058651	·001745201
574	329476	189119224	23·9582971	8·3106941	·001742160
575	330625	190109375	23·9791576	8·3155175	·001739130
576	331776	191102976	24·0000000	8·3203353	·001736111
577	332929	192100033	24·0208243	8·3251475	·001733102
578	334084	193100552	24·0416306	8·3299542	·001730104
579	335241	194104539	24·0624188	8·3347553	·001727116
580	336400	195112000	24·0831891	8·3395509	·001724138
581	337561	196122941	24·1039416	8·3443410	·001721170
582	338724	197137368	24·1246762	8·3491256	·001718213
583	339889	198155287	24·1453929	8·3539047	·001715266
584	341056	199176704	24·1660919	8·3586784	·001712329

No.	Square	Cube	Square Root	Cube Root	Reciprocal
585	342225	200201625	24·1867732	8·3634466	·001709402
586	343396	201230056	24·2074369	8·3682095	·001706485
587	344569	202262003	24·2280829	8·3729668	·001703578
588	345744	203297472	24·2487113	8·3777188	·005700680
589	346921	204336469	24·2693222	8·3824653	·001697793
590	348100	205379000	24·2899156	8·3872065	·001694915
591	349281	206425071	24·3104916	8·3919423	·001692047
592	350464	207474688	24·3310501	8·3966729	·001689189
593	351649	208527857	24·3515913	8·4013981	·001686341
594	352836	209584584	24·3721152	8·4061180	·001683502
595	354025	210644875	24·3926218	8·4108326	·001680672
596	355216	211708736	24·4131112	8·4155419	·001677852
597	356409	212776173	24·4335834	8·4202460	·001675042
598	357604	213847192	24·4540385	8·4249448	·001672241
599	358801	214921799	24·4744765	8·4296383	·001669449
600	360000	216000000	24·4948974	8·4343267	·001666667
601	361201	217081801	24·5153013	8·4390098	·001663894
602	362404	218167208	24·5356883	8·4436877	·001661130
603	363609	219256227	24·5560583	8·4483605	·001658375
604	364816	220348864	24·5764115	8·4530281	·001655629
605	366025	221445125	24·5967478	8·4576906	·001652893
606	367236	222545016	24·6170673	8·4623479	·001650165
607	368449	223648543	24·6373700	8·4670000	·001647446
608	369664	224755712	24·6576560	8·4716471	·001644737
609	370881	225866529	24·6779254	8·4762892	·001642036
610	372100	226981000	24·6981781	8·4809261	·001639344
611	373321	228099131	24·7184142	8·4855579	·001636661
612	374544	229220928	24·7386338	8·4901848	·001633987
613	375769	230346397	24·7588368	8·4948065	·001631321
614	376996	231475544	24·7790234	8·4994233	·001628664
615	378225	232608375	24·7991935	8·5040350	·001626016
616	379456	233744896	24·8193473	8·5086417	·001623377
617	380689	234885113	24·8394847	8·5132435	·001620746
618	381924	236029032	24·8596058	8·5178403	·001618123
619	383161	237176659	24·8797106	8·5224321	·001615509
620	384400	238328000	24·8997992	8·5270189	·001612903
621	385641	239483061	24·9198716	8·5316009	·001610306
622	386884	240641848	24·9399278	8·5361780	·001607717
623	388129	241804367	24·9599679	8·5407501	·001605136
624	389376	242970624	24·9799920	8·5453173	·001602564
625	390625	244140625	25·0000000	8·5498797	·001600000
626	391876	245314376	25·0199920	8·5544372	·001597444
627	393129	246491883	25·0399681	8·5589899	·001594896
628	394384	247673152	25·0599282	8·5635377	·001592357
629	395641	248858189	25·0798724	8·5680807	·001589825
630	396900	250047000	25·0998008	8·5726189	·001587302
631	398161	251239591	25·1197134	8·5771523	·001584786
632	399424	252435968	25·1396102	8·5816809	·001582278
633	400689	253636137	25·1594913	8·5862047	·001579779

No.	Square	Cube	Square Root	Cube Root	Reciprocal
634	401956	254840104	25·1793566	8·5907238	·001577287
635	403225	256047875	25·1992063	8·5952380	·001574803
636	404496	257259456	25·2190404	8·5997476	·001572327
637	405769	258474853	25·2388589	8·6042525	·001569859
638	407044	259694072	25·2586619	8·6087526	·001567398
639	408321	260917119	25·2784493	8·6132480	·001564945
640	409600	262144000	25·2982213	8·6177388	·001562500
641	410881	263374721	25·3179778	8·6222248	·001560062
642	412164	264609288	25·3377189	8·6267063	·001557632
643	413449	265847707	25·3574447	8·6311830	·001555210
644	414736	267089984	25·3771551	8·6356551	·001552795
645	416025	268336125	25·3968502	8·6401226	·001550388
646	417316	269586136	25·4165301	8·6445855	·001547988
647	418609	270840023	25·4361947	8·6490437	·001545595
648	419904	272097792	25·4558441	8·6534974	·001543210
649	421201	273359449	25·4754784	8·6579465	·001540832
650	422500	274625000	25·4950976	8·6623911	·001538462
651	423801	275894451	25·5147016	8·6668310	·001536098
652	425104	277167808	25·5342907	8·6712665	·001533742
653	426409	278445077	25·5538647	8·6756974	·001531394
654	427716	279726264	25·5734237	8·6801237	·001529052
655	429025	281011375	25·5929678	8·6845456	·001526718
656	430336	282300416	25·6124969	8·6889630	·001524390
657	431649	283593393	25·6320112	8·6933759	·001522070
658	432964	284890312	25·6515107	8·6977843	·001519757
659	434281	286191179	25·6709953	8·7021882	·001517451
660	435600	287496000	25·6904652	8·7065877	·001515152
661	436921	288804781	25·7099203	8·7109827	·001512859
662	438244	290117528	25·7293607	8·7153734	·001510574
663	439569	291434247	25·7487864	8·7197596	·001508296
664	440896	292754944	25·7681975	8·7241414	·001506024
665	442225	294079625	25·7875939	8·7285187	·001503759
666	443556	295408296	25·8069758	8·7328918	·001501502
667	444889	296740963	25·8263431	8·7372604	·001499250
668	446224	298077632	25·8456960	8·7416246	·001497006
669	447561	299418309	25·8650343	8·7459846	·001494768
670	448900	300763000	25·8843582	8·7503401	·001492537
671	450241	302111711	25·9036677	8·7546913	·001490313
672	451584	303464448	25·9229628	8·7590383	·001488095
673	452929	304821217	25·9422435	8·7633809	·001485884
674	454276	306182024	25·9615100	8·7677192	·001483680
675	455625	307546875	25·9807621	8·7720532	·001481481
676	456976	308915776	26·0000000	8·7763830	·001479290
677	458329	310288733	26·0192237	8·7807084	·001477105
678	459684	311665752	26·0384331	8·7850296	·001474926
679	461041	313046839	26·0576284	8·7893466	·001472754
680	462400	314432000	26·0768096	8·7936593	·001470588
681	463761	315821241	26·0959767	8·7979679	·001468429
682	465124	317214568	26·1151297	8·8022721	·001466276

No.	Square	Cube	Square Root	Cube Root	Reciprocal
683	466489	318611987	26·1342687	8·8065722	·001464129
684	467856	320013504	26·1533937	8·8108681	·001461988
685	469225	321419125	26·1725047	8·8151598	·001459854
686	470596	322828856	26·1916017	8·8194474	·001457726
687	471969	324242703	26·2106848	8·8237307	·001455604
688	473344	325660672	26·2297541	8·8280099	·001453488
689	474721	327082769	26·2488095	8·8322850	·001451379
690	476100	328509000	26·2678511	8·8365559	·001449275
691	477481	329939371	26·2868789	8·8408227	·001447178
692	478864	331373888	26·3058929	8·8450854	·001445087
693	480249	332812557	26·3248932	8·8493440	·001443001
694	481636	334255384	26·3438797	8·8535985	·001440922
695	483025	335702375	26·3628527	8·8578489	·001438849
696	484416	337153536	26·3818119	8·8620952	·001436782
697	485809	338608873	26·4007576	8·8663375	·001434720
698	487204	340068392	26·4196896	8·8705757	·001432665
699	488601	341532099	26·4386081	8·8748099	·001430615
700	490000	343000000	26·4575131	8·8790400	·001428571
701	491401	344472101	26·4764046	8·8832661	·001426534
702	492804	345948408	26·4952826	8·8874882	·001424501
703	494209	347428927	26·5141472	8·8917063	·001422475
704	495616	348913664	26·5329983	8·8959204	·001420455
705	497025	350402625	26·5518361	8·9001304	·001418440
706	498436	351895816	26·5706605	8·9043366	·001416431
707	499849	353393243	26·5894716	8·9085387	·001414427
708	501264	354894912	26·6082694	8·9127369	·001412429
709	502681	356400829	26·6270539	8·9169311	·001410437
710	504100	357911000	26·6458252	8·9211214	·001408451
711	505521	359425431	26·6645833	8·9253078	·001406470
712	506944	360944128	26·6833281	8·9294902	·001404494
713	508369	362467097	26·7020598	8·9336687	·001402525
714	509796	363994344	26·7207784	8·9378433	·001400560
715	511225	365525875	26·7394839	8·9420140	·001398601
716	512656	367061696	26·7581763	8·9461809	·001396648
717	514089	368601813	26·7768557	8·9503438	·001394700
718	515524	370146232	26·7955220	8·9545029	·001392758
719	516961	371694959	26·8141754	8·9586581	·001390821
720	518400	373248000	26·8328157	8·9628095	·001388889
721	519841	374805361	26·8514432	8·9669570	·001386963
722	521284	376367048	26·8700577	8·9711007	·001385042
723	522729	377933067	26·8886593	8·9752406	·001383126
724	524176	379503424	26·9072481	8·9793766	·001381215
725	525625	381078125	26·9258240	8·9835089	·001379310
726	527076	382657176	26·9443872	8·9876373	·001377410
727	528529	384240583	26·9629375	8·9917620	·001375516
728	529984	385828352	26·9814751	8·9958829	·001373626
729	531441	387420489	27·0000000	9·0000000	·001371742
730	532900	389017000	27·0185122	9·0041134	·001369863
731	534361	390617891	27·0370117	9·0082229	·001367989

No.	Square	Cube	Square Root	Cube Root	Reciprocal
732	535824	392223168	27·0554985	9·0123288	·001366120
733	537289	393832837	27·0739727	9·0164309	·001364256
734	538756	395446904	27·0924344	9·0205293	·001362398
735	540225	397065375	27·1108834	9·0246239	·001360544
736	541696	398688256	27·1293199	9·0287149	·001358696
737	543169	400315553	27·1477439	9·0328021	·001356852
738	544644	401947272	27·1661554	9·0368857	·001355014
739	546121	403583419	27·1845544	9·0409655	·001353180
740	547600	405224000	27·2029410	9·0450417	·001351351
741	549081	406869021	27·2213152	9·0491142	·001349528
742	550564	408518488	27·2396769	9·0531831	·001347709
743	552049	410172407	27·2580263	9·0572482	·001345895
744	553536	411830784	27·2763634	9·0613098	·001344086
745	555025	413493625	27·2946881	9·0653677	·001342282
746	556516	415160936	27·3130006	9·0694220	·001340483
747	558009	416832723	27·3313007	9·0734726	·001338688
748	559504	418508992	27·3495887	9·0775197	·001336898
749	561001	420189749	27 3678644	9·0815631	·001335113
750	562500	421875000	27·3861279	9·0856030	·001333333
751	564001	423564751	27·4043792	9·0896392	·001331558
752	565504	425259008	27·4226184	9·0936719	·001329787
753	567009	426957777	27·4408455	9·0977010	·001328021
754	568516	428661064	27·4590604	9·1017265	·001326260
755	570025	430368875	27·4772633	9·1057485	·001324503
756	571536	432081216	27·4954542	9·1097669	·001322751
757	573049	433798093	27·5136330	9·1137818	·001321004
758	574564	435519512	27·5317998	9·1177931	·001319261
759	576081	437245479	27·5499546	9·1218010	·001317523
760	577600	438976000	27·5680975	9·1258053	·001315789
761	579121	440711081	27·5862284	9·1298061	·001314060
762	580644	442450728	27·6043475	9·1338034	·001312336
763	582169	444194947	27·6224546	9·1377971	·001310616
764	583696	445943744	27·6405499	9·1417874	·001308901
765	585225	447697125	27·6586334	9·1457742	·001307190
766	586756	449455096	27·6767050	9·1497576	·001305483
767	588289	451217663	27·6947648	9·1537375	·001303781
768	589824	452984832	27·7128129	9·1577139	·00 302083
769	591361	454756609	27·7308492	9·1616869	·001300390
770	592900	456533000	27·7488739	9·1656565	·001298701
771	594441	458314011	27·7668868	9·1696225	·001297017
772	595984	460099648	27·7848880	9·1735852	·001295337
773	597529	461889917	27·8028775	9·1775445	·001293661
774	599076	463684824	27·8208555	9·1815003	·001291990
775	600625	465484375	27·8388218	9·1854527	·001290323
776	602176	467288576	27·8567766	9·1894018	·001288660
777	603729	469097433	27·8747197	9·1933474	·001287001
778	605284	470910952	27·8926514	9·1972897	·001285347
779	606841	472729139	27·9105715	9·2012286	·001283697
780	608400	474552000	27·9284801	9·2051641	·001282051

No.	Square	Cube	Square Root	Cube Root	Reciprocal
781	609961	476379541	27·9463772	9·2090962	·001280410
782	611524	478211768	27·9642629	9·2130250	·001278772
783	613089	480048687	27·9821372	9·2169505	·001277139
784	614656	481890304	28·0000000	9·2208726	·001275510
785	616225	483736625	28·0178515	9·2247914	·001273885
786	617796	485587656	28·0356915	9·2287068	·001272265
787	619369	487443403	28·0535203	9·2326189	·001270648
788	620944	489303872	28·0713377	9·2365277	·001269036
789	622521	491169069	28·0891438	9·2404333	·001267427
790	624100	493039000	28·1069386	9·2443355	·001265823
791	625681	494913671	28·1247222	9·2482344	·001264223
792	627264	496793088	28·1424946	9·2521300	·001262626
793	628849	498677257	28·1602557	9·2560224	·001261034
794	630436	500566184	28·1780056	9·2599114	·001259446
795	632025	502459875	28·1957444	9·2637973	·001257862
796	633616	504358336	28·2134720	9·2676798	·001256281
797	635209	506261573	28·2311884	9·2715592	·001254705
798	636804	508169592	28·2488938	9·2754352	·001253133
799	638401	510082399	28·2665881	9·2793081	·001251564
800	640000	512000000	28·2842712	9·2831777	·001250000
801	641601	513922401	28·3019434	9·2870440	·001248439
802	643204	515849608	28·3196045	9·2909072	·001246883
803	644809	517781627	28·3372546	9·2947671	·001245330
804	646416	519718464	28·3548938	9·2986239	·001243781
805	648025	521660125	28·3725219	9·3024775	·001242236
806	649636	523606616	28·3901391	9·3063278	·001240695
807	651249	525557943	28·4077454	9·3101750	·001239157
808	652864	527514112	28·4253408	9·3140190	·001237624
809	654481	529475129	28·4429253	9·3178599	·001236094
810	656100	531441000	28·4604989	9·3216975	·001234568
811	657721	533411731	28·4780617	9·3255320	·001233046
812	659344	535387328	28·4956137	9·3293634	·001231527
813	660969	537367797	28·5131549	9·3331916	·001230012
814	662596	539353144	28·5306852	9·3370167	·001228501
815	664225	541343375	28·5482048	9·3408386	·001226994
816	665856	543338496	28·5657137	9·3446575	·001225490
817	667489	545338513	28·5832119	9·3484731	·001223990
818	669124	547343432	28·6006993	9·3522857	·001222494
819	670761	549353259	28·6181760	9·3560952	·001221001
820	672400	551368000	28·6356421	9·3599016	·001219512
821	674041	553387661	28·6530976	9·3637049	·001218027
822	675684	555412248	28·6705424	9·3675051	·001216545
823	677329	557441767	28·6879766	9·3713022	·001215067
824	678976	559476224	28·7054002	9·3750963	·001213592
825	680625	561515625	28·7228132	9·3788873	·001212121
826	682276	563559976	28·7402157	9·3826752	·001210654
827	683929	565609283	28·7576077	9·3864600	·001209190
828	685584	567663552	28·7749891	9·3902419	·001207729
829	687241	569722789	28·7923601	9·3940206	·001206272

No.	Square	Cube	Square Root	Cube Root	Reciprocal
830	688900	571787000	28·8097206	9·3977964	·001204819
831	690561	573856191	28·8270706	9·4015691	·001203369
832	692224	575930368	28·8444102	9·4053387	·001201923
833	693889	578009537	28·8617394	9·4091054	·001200480
834	695556	580093704	28·8790582	9·4128690	·001199041
835	697225	582182875	28·8963666	9·4166297	·001197605
836	698896	584277056	28·9136646	9·4203873	·001196172
837	700569	586376253	28·9309523	9·4241420	·001194743
838	702244	588480472	28·9482297	9·4278936	·001193317
839	703921	590589719	28·9654967	9·4316423	·001191895
840	705600	592704000	28·9827535	9·4353880	·001190476
841	707281	594823321	29·0000000	9·4391307	·001189061
842	708964	596947688	29·0172363	9·4428704	·001187648
843	710649	599077107	29·0344623	9·4466072	·001186240
844	712336	601211584	29·0516781	9·4503410	·001184834
845	714025	603351125	29·0688837	9·4540719	·001183432
846	715716	605495736	29·0860791	9·4577999	·001182033
847	717409	607645423	29·1032644	9·4615249	·001180638
848	719104	609800192	29·1204396	9·4652470	·001179245
849	720801	611960049	29·1376046	9·4689661	·001177856
850	722500	614125000	29·1547595	9·4726824	·001176471
851	724201	616295051	29·1719043	9·4763957	·001175088
852	725904	618470208	29·1890390	9·4801061	·001173709
853	727609	620650477	29·2061637	9·4838136	·001172333
854	729316	622835864	29·2232784	9·4875182	·001170960
855	731025	625026375	29·2403830	9·4912200	·001169591
856	732736	627222016	29·2574777	9·4949188	·001168224
857	734449	629422793	29·2745623	9·4986147	·001166861
858	736164	631628712	29·2916370	9·5023078	·001165501
859	737881	633839779	29·3087018	9·5059980	·001164144
860	739600	636056000	29·3257566	9·5096854	·001162791
861	741321	638277381	29·3428015	9·5133699	·001161440
862	743044	640503928	29·3598365	9·5170515	·001160093
863	744769	642735647	29·3768616	9·5207303	·001158749
864	746496	644972544	29·3938769	9·5244063	·001157407
865	748225	647214625	29·4108823	9·5280794	·001156069
866	749956	649461896	29·4278779	9·5317497	·001154734
867	751689	651714363	29·4448637	9·5354172	·001153403
868	753424	653972032	29·4618397	9·5390818	·001152074
869	755161	656234909	29·4788059	9·5427437	·001150748
870	756900	658503000	29·4957624	9·5464027	·001149425
871	758641	660776311	29·5127091	9·5500589	·001148106
872	760384	663054848	29·5296461	9·5537123	·001146789
873	762129	665338617	29·5465734	9·5573630	·001145475
874	763876	667627624	29·5634910	9·5610108	·001144165
875	765625	669921875	29·5803989	9·5646559	·001142857
876	767376	672221376	29·5972972	9·5682982	·001141553
877	769129	674526133	29·6141858	9·5719377	·001140251
878	770884	676836152	29·6310648	9·5755745	·001138952

No.	Square	Cube	Square Root	Cube Root	Reciprocal
879	772641	679151439	29·6479342	9·5792085	·001137656
880	774400	681472000	29·6647939	9·5828397	·001136364
881	776161	683797841	29·6816442	9·5864682	·001135074
882	777924	686128968	29·6984848	9·5900939	·001133787
883	779689	688465387	29·7153159	9·5937169	·001132503
884	781456	690807104	29·7321375	9·5973373	·001131222
885	783225	693154125	29·7489496	9·6009548	·001129944
886	784996	695506456	29·7657521	9·6045696	·001128668
887	786769	697864103	29·7825452	9·6081817	·001127396
888	788544	700227072	29·7993289	9·6117911	·001126126
889	790321	702595369	29·8161030	9·6153977	·001124859
890	792100	704969000	29·8328678	9·6190017	·001123596
891	793881	707347971	29·8496231	9·6226030	·001122334
892	795664	709732288	29·8663690	9·6262016	·001121076
893	797449	712121957	29·8831056	9·6297975	·001119821
894	799236	714516984	29·8998328	9·6333907	·001118568
895	801025	716917375	29·9165506	9·6369812	·001117318
896	802816	719323136	29·9332591	9·6405690	·001116071
897	804609	721734273	29·9499583	9·6441542	·001114827
898	806404	724150792	29·9666481	9·6477367	·001113586
899	808201	726572699	29·9833287	9·6513166	·001112347
900	810000	729000000	30·0000000	9·6548938	·001111111
901	811801	731432701	30·0166620	9·6584684	·001109878
902	813604	733870808	30·0333148	9·6620403	·001108647
903	815409	736314327	30·0499584	9·6656096	·001107420
904	817216	738763264	30·0665928	9·6691762	·001106195
905	819025	741217625	30·0832179	9·6727403	·001104972
906	820836	743677416	30·0998339	9·6763017	·001103753
907	822649	746142643	30·1164407	9·6798604	·001102536
908	824464	748613312	30·1330383	9·6834166	·001101322
909	826281	751089429	30·1496269	9·6869701	·001100110
910	828100	753571000	30·1662063	9·6905211	·001098901
911	829921	756058031	30·1827765	9·6940694	·001097695
912	831744	758550528	30·1993377	9·6976151	·001096491
913	833569	761048497	30·2158899	9·7011583	·001095290
914	835396	763551944	30·2324329	9·7046989	·001094092
915	837225	766060875	30·2489669	9·7082369	·001092896
916	839056	768575296	30·2654919	9·7117723	·001091703
917	840889	771095213	30·2820079	9·7153051	·001090513
918	842724	773620632	30·2985148	9·7188354	·001089325
919	844561	776151559	30·3150128	9·7223631	·001088139
920	846400	778688000	30·3315018	9·7258883	·001086957
921	848241	781229961	30·3479818	9·7294109	·001085776
922	850084	783777448	30·3644529	9·7329309	·001084599
923	851929	786330467	30·3809151	9·7364484	·001083424
924	853776	788889024	39·3973683	9·7399634	·001082251
925	855625	791453125	30·4138127	9·7434758	·001081081
926	857476	794022776	30·4302481	9·7469857	·001079914
927	859329	796597983	30·4466747	9·7504930	·001078749

No.	Square	Cube	Square Root	Cube Root	Reciprocal
928	861184	799178752	30·4630924	9·7539979	·001077586
929	863041	801765089	30·4795013	9·7575002	·001076426
930	864900	804357000	30·4959014	9·7610001	·001075269
931	866761	806954491	30·5122926	9·7644974	·001074114
932	868624	809557568	30·5286750	9·7679922	·001072961
933	870489	812166237	30·5450487	9·7714845	·001071811
934	872356	814780504	30·5614136	9·7749743	·001070664
935	874225	817400375	30·5777697	9·7784616	·001069519
936	876096	820025856	30·5941171	9·7819466	·001068376
937	877969	822656953	30·6104557	9·7854288	·001067236
938	879844	825293672	30·6267857	9·7889087	·001066098
939	881721	827936019	30·6431069	9·7923861	·001064963
940	883600	830584000	30·6594194	9·7958611	·001063830
941	885481	833237621	30·6757233	9·7993336	·001062699
942	887364	835896888	30·6920185	9·8028036	·001061571
943	889249	838561807	30·7083051	9·8062711	·001060445
944	891136	841232384	30·7245830	9·8097362	·001059322
945	893025	843908625	30·7408523	9·8131989	·001058201
946	894916	846590536	30·7571130	9·8166591	·001057082
947	896809	849278123	30·7733651	9·8201169	·001055966
948	898704	851971392	30·7896086	9·8235723	·001054852
949	900601	854670349	30·8058436	9·8270252	·001053741
950	902500	857375000	30·8220700	9·8304757	·001052632
951	904401	860085351	30·8382879	9·8339238	·001051525
952	906304	862801408	30·8544972	9·8373695	·001050420
953	908209	865523177	30·8706981	9·8408127	·001049318
954	910116	868250664	30·8868904	9·8442536	·001048218
955	912025	870983875	30·9030743	9·8476920	·001047120
956	913936	873722816	30·9192497	9·8511280	·001046025
957	915849	876467493	30·9354166	9·8545617	·001044932
958	917764	879217912	30·9515751	9·8579929	·001043841
959	919681	881974079	30·9677251	9·8614218	·001042753
960	921600	884736000	30·9838668	9·8648483	·001041667
961	923521	887503681	31·0000000	9·8682724	·001040583
962	925444	890277128	31·0161248	9·8716941	·001039501
963	927369	893056347	31·0322413	9·8751135	·001038422
964	929296	895841344	31·0483494	9·8785305	·001037344
965	931225	898632125	31·0644491	9·8819451	·001036269
966	933156	901428696	31·0805405	9·8853574	·001035197
967	935089	904231063	31·0966236	9·8887673	·001034126
968	937024	907039232	31·1126984	9·8921749	·001033058
969	938961	909853209	31·1287648	9·8955801	·001031992
970	940900	912673000	31·1448230	9·8989830	·001030928
971	942841	915498611	31·1608729	9·9023835	·001029866
972	944784	918330048	31·1769145	9·9057817	·001028807
973	946729	921167317	31·1929479	9·9091776	·001027749
974	948676	924010424	31·2089731	9·9125712	·001026694
975	950625	926859375	31·2249900	9·9159624	·001025641
976	952576	929714176	31·2409987	9·9193513	·001024590

No.	Square	Cube	Square Root	Cube Root	Reciprocal
977	954529	932574833	31·2569992	9·9227879	·001023541
978	956484	935441352	31·2729915	9·9261222	·001022495
979	958441	938313739	31·2889757	9·9295042	·001021450
980	960400	941192000	31·3049517	9·9328839	·001020408
981	962361	944076141	31·3209195	9·9362613	·001019368
982	964324	946966168	31·3368792	9·9396363	·001018330
983	966289	949862087	31·3528308	9·9430092	·001017294
984	968256	952763904	31·3687743	9·9463797	·001016260
985	970225	955671625	31·3847097	9·9497479	·001015228
986	972196	958585256	31·4006369	9·9531138	·001014199
987	974169	961504803	31·4165561	9·9564775	·001013171
988	976144	964430272	31·4324673	9·9598389	·001012146
989	978121	967361669	31·4483704	9·9631981	·001011122
990	980100	970299000	31·4642654	9·9665549	·001010101
991	982081	973242271	31·4801525	9·9699095	·001009082
992	984064	976191488	31·4960315	9·9732619	·001008065
993	986049	979146657	31·5119025	9·9766120	·001007049
994	988036	982107784	31·5277655	9·9799599	·001006036
995	990025	985074875	31·5436206	9 9833055	·001005025
996	992016	988047936	31·5594677	9·9866488	·001004016
997	994009	991026973	31·5753068	9·9899900	·001003009
998	996004	994011992	31·5911380	9·9933289	·001002004
999	998001	997002999	31·6069613	9·9966656	·001001001
1000	1000000	1000000000	31·6227766	10·0000000	·0010000000
1001	1002001	1003003001	31·6385840	10·0033322	·0009990010
1002	1004004	1006012008	31·6543836	10·0066622	·0009980040
1003	1006009	1009027027	31·6701752	10·0099899	·0009970090
1004	1008016	1012048064	31·6859590	10·0133155	·0009960159
1005	1010025	1015075125	31·7017349	10·0166389	·0009950249
1006	1012036	1018108216	31·7175030	10·0199601	·0009940358
1007	1014049	1021147343	31·7332633	10·0232791	·0009930487
1008	1016064	1024192512	31·7490157	10·0265958	·0009920635
1009	1018081	1027243729	31·7647603	10·0299104	·0009910803
1010	1020100	1030301000	31·7804972	10·0332228	·0009900990
1011	1022121	1033364331	31·7962262	10·0365330	·0009891197
1012	1024144	1036433728	31·8119474	10·0398410	·0009881423
1013	1026169	1039509197	31·8276609	10·0431469	·0009871668
1014	1028196	1042590744	31·8433666	10·0464506	·0009861933
1015	1030225	1045678375	31·8590646	10·0497521	·0009852217
1016	1032256	1048772096	31·8747549	10·0530514	·0009842520
1017	1034289	1051871913	31·8904374	10·0563485	·0009832842
1018	1036324	1054977832	31·9061123	10·0596435	·0009823183
1019	1038361	1058089859	31·9217794	10·0629364	·0009813543
1020	1040400	1061208000	31·9374388	10·0662271	·0009803922
1021	1042441	1064332261	31·9530906	10·0695156	·0009794319
1022	1044484	1067462648	31·9687347	10·0728020	·0009784736
1023	1046529	1070599167	31·9843712	10·0760863	·0009775171
1024	1048576	1073741824	32·0000000	10·0793684	·0009765625
1025	1050625	1076890625	32·0156212	10·0826484	·0009756098

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1026	1052676	1080045576	32·0312348	10·0859262	·0009746589
1027	1054729	1083206683	32·0468407	10·0892019	·0009737098
1028	1056784	1086373952	32·0624391	10·0924755	·0009727626
1029	1058841	1089547389	32·0780298	10·0957469	·0009718173
1030	1060900	1092727000	32·0936131	10·0990163	·0009708738
1031	1062961	1095912791	32·1091887	10·1022835	·0009699321
1032	1065024	1099104768	32·1247568	10·1055487	·0009689922
1033	1067089	1102302937	32·1403173	10·1088117	·0009680542
1034	1069156	1105507304	32·1558704	10·1120726	·0009671180
1035	1071225	1108717875	32·1714159	10·1153314	·0009661836
1036	1073296	1111934656	32·1869539	10·1185882	·0009652510
1037	1075369	1115157653	32·2024844	10·1218428	·0009643202
1038	1077444	1118386872	32·2180074	10·1250953	·0009633911
1039	1079521	1121622319	32·2335229	10·1283457	·0009624639
1040	1081600	1124864000	32·2490310	10·1315941	·0009615385
1041	1083681	1128111921	32·2645316	10·1348403	·0009606148
1042	1085764	1131366088	32·2800248	10·1380845	·0009596929
1043	1087849	1134626507	32·2955105	10·1413266	·0009587728
1044	1089936	1137893184	32·3109888	10·1445667	·0009578544
1045	1092025	1141166125	32·3264598	10·1478047	·0009569378
1046	1094116	1144445336	32·3419233	10·1510406	·0009560229
1047	1096209	1147730823	32·3573794	10·1542744	·0009551098
1048	1098304	1151022592	32·3728281	10·1575062	·0009541985
1049	1100401	1154320649	32·3882695	10·1607359	·0009532888
1050	1102500	1157625000	32·4037035	10·1639636	·0009523810
1051	1104601	1160935651	32·4191301	10·1671893	·0009514748
1052	1106704	1164252608	32·4345495	10·1704129	·0009505703
1053	1108809	1167575877	32·4499615	10·1736344	·0009496676
1054	1110916	1170905464	32·4653662	10·1768539	·0009487666
1055	1113025	1174241375	32·4807635	10·1800714	·0009478673
1056	1115136	1177583616	32·4961536	10·1832868	·0009469697
1057	1117249	1180932193	32·5115364	10·1865002	·0009460738
1058	1119364	1184287112	32·5269119	10·1897116	·0009451796
1059	1121481	1187648379	32·5422802	10·1929209	·0009442871
1060	1123600	1191016000	32·5576412	10·1961283	·0009433962
1061	1125721	1194389981	32 5729949	10·1993336	·0009425071
1062	1127844	1197770328	32·5883415	10·2025369	·0009416196
1063	1129969	1201157047	32·6036807	10·2057382	·0009407338
1064	1132096	1204550144	32·6190129	10·2089375	·0009398496
1065	1134225	1207949625	32·6343377	10·2121347	·0009389671
1066	1136356	1211355496	32·6496554	10·2153300	·0009380863
1067	1138489	1214767763	32·6649659	10·2185233	·0009372071
1068	1140624	1218186432	32·6802693	10·2217146	·0009363296
1069	1142761	1221611509	32·6955654	10·2249039	·0009354537
1070	1144900	1225043000	32·7108544	10·2280912	·0009345794
1071	1147041	1228480911	32·7261363	10·2312766	·0009337068
1072	1149184	1231925248	32·7414111	10·2344599	·0009328358
1073	1151329	1235376017	32·7566787	10·2376413	·0009319664
1074	1153476	1238833224	32·7719392	10·2408207	·0009310987

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1075	1155625	1242296875	32·7871926	10·2439981	·0009302326
1076	1157776	1245766976	32·8024389	10·2471735	·0009293680
1077	1159929	1249243533	32·8176782	10·2503470	·0009285051
1078	1162084	1252726552	32·8329103	10·2535186	·0009276438
1079	1164241	1256216039	32·8481354	10·2566881	·0009267841
1080	1166400	1259712000	32·8633535	10·2598557	·0009259259
1081	1168561	1263214441	32·8785644	10·2630213	·0009250694
1082	1170724	1266723368	32·8937684	10·2661850	·0009242144
1083	1172889	1270238787	32·9089653	10·2693467	·0009233610
1084	1175056	1273760704	32·9241553	10·2725065	·0009225092
1085	1177225	1277289125	32·9393382	10·2756644	·0009216590
1086	1179396	1280824056	32·9545141	10·2788203	·0009208103
1087	1181569	1284365503	32·9696830	10·2819743	·0009199632
1088	1183744	1287913472	32·9848450	10·2851264	·0009191176
1089	1185921	1291467969	33·0000000	10·2882765	·0009182736
1090	1188100	1295029000	33·0151480	10·2914247	·0009174312
1091	1190281	1298596571	33·0302891	10·2945709	·0009165903
1092	1192464	1302170688	33·0454233	10·2977153	·0009157509
1093	1194649	1305751357	33·0605505	10·3008577	·0009149131
1094	1196836	1309338584	33·0756708	10·3039982	·0009140768
1095	1199025	1312932375	33·0907842	10·3071368	·0009132420
1096	1201216	1316532736	33·1058907	10·3102735	·0009124088
1097	1203409	1320139673	33·1209903	10·3134083	·0009115770
1098	1205604	1323753192	33·1360830	10·3165411	·0009107468
1099	1207801	1327373299	33·1511689	10·3196721	·0009099181
1100	1210000	1331000000	33·1662479	10·3228012	·0009090909
1101	1212201	1334633301	33·1813200	10·3259284	·0009082652
1102	1214404	1338273208	33·1963853	10·3290537	·0009074410
1103	1216609	1341919727	33·2114438	10·3321770	·0009066183
1104	1218816	1345572864	33·2264955	10·3352985	·0009057971
1105	1221025	1349232625	33·2415403	10·3384181	·0009049774
1106	1223236	1352899016	33·2565783	10·3415358	·0009041591
1107	1225449	1356572043	33·2716095	10·3446517	·0009033424
1108	1227664	1360251712	33·2866339	10·3477657	·0009025271
1109	1229881	1363938029	33·3016516	10·3508778	·0009017133
1110	1232100	1367631000	33·3166625	10·3539880	·0009009009
1111	1234321	1371330631	33·3316666	10·3570964	·0009000900
1112	1236544	1375036928	33·3466640	10·3602029	·0008992806
1113	1238769	1378749897	33·3616546	10·3633076	·0008984726
1114	1240996	1382469544	33·3766385	10·3664103	·0008976661
1115	1243225	1386195875	33·3916157	10·3695113	·0008968610
1116	1245456	1389928896	33·4065862	10·3726103	·0008960573
1117	1247689	1393668613	33·4215499	10·3757076	·0008952551
1118	1249924	1397415032	33·4365070	10·3788030	·0008944544
1119	1252161	1401168159	33·4514573	10·3818965	·0008936550
1120	1254400	1404928000	33·4664011	10·3849882	·0008928571
1121	1256641	1408694561	33·4813381	10·3880781	·0008920607
1122	1258884	1412467848	33·4962684	10·3911661	·0008912656
1123	1261129	1416247867	33·5111921	10·3942523	·0008904720

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1124	1263376	1420034624	33·5261092	10·3973366	·0008896797
1125	1265625	1423828125	33·5410196	10·4004192	·0008888889
1126	1267876	1427628376	33·5559234	10·4034999	·0008880995
1127	1270129	1431435383	33·5708206	10·4065787	·0008873114
1128	1272384	1435249152	33·5857112	10·4096557	·0008865248
1129	1274641	1439069689	33·6005952	10·4127310	·0008857396
1130	1276900	1442897000	33·6154726	10·4158044	·0008849558
1131	1279161	1446731091	33·6303434	10·4188760	·0008841733
1132	1281424	1450571968	33·6452077	10·4219458	·0008833922
1133	1283689	1454419637	33·6600653	10·4250138	·0008826125
1134	1285956	1458274104	33·6749165	10·4280800	·0008818342
1135	1288225	1462135375	33·6897610	10·4311443	·0008810573
1136	1290496	1466003456	33·7045991	10·4342069	·0008802817
1137	1292769	1469878353	33·7194306	10·4372677	·0008795075
1138	1295044	1473760072	33·7342556	10·4403267	·0008787346
1139	1297321	1477648619	33·7490741	10·4433839	·0008779631
1140	1299600	1481544000	33·7638860	10·4464393	·0008771930
1141	1301881	1485446221	33·7786915	10·4494929	·0008764242
1142	1304164	1489355288	33·7934905	10·4525448	·0008756567
1143	1306449	1493271207	33·8082830	10·4555948	·0008748906
1144	1308736	1497193984	33·8230691	10·4586431	·0008741259
1145	1311025	1501123625	33·8378486	10·4616896	·0008733624
1146	1313316	1505060136	33·8526218	10·4647343	·0008726003
1147	1315609	1509003523	33·8673884	10·4677773	·0008718396
1148	1317904	1512953792	33·8821487	10·4708185	·0008710801
1149	1320201	1516910949	33·8969025	10·4738579	·0008703220
1150	1322500	1520875000	33·9116499	10·4768955	·0008695652
1151	1324801	1524845951	33·9263909	10·4799314	·0008688097
1152	1327104	1528823808	33·9411255	10·4829656	·0008680556
1153	1329409	1532808577	33·9558537	10·4859980	·0008673027
1154	1331716	1536800264	33·9705755	10·4890286	·0008665511
1155	1334025	1540798875	33·9852910	10·4920575	·0008658009
1156	1336336	1544804416	34·0000000	10·4950847	·0008650519
1157	1338649	1548816893	34·0147027	10·4981101	·0008643042
1158	1340964	1552836312	34·0293990	10·5011337	·0008635579
1159	1343281	1556862679	34·0440890	10·5041556	·0008628128
1160	1345600	1560896000	34·0587727	10·5071757	·0008620690
1161	1347921	1564936281	34·0734501	10·5101942	·0008613264
1162	1350244	1568983528	34·0881211	10·5132109	·0008605852
1163	1352569	1573037747	34·1027858	10·5162259	·0008598452
1164	1354896	1577098944	34·1174442	10·5192391	·0008591065
1165	1357225	1581167125	34·1320963	10·5222506	·0008583691
1166	1359556	1585242296	34·1467422	10·5252604	·0008576329
1167	1361889	1589324463	34·1613817	10·5282685	·0008568980
1168	1364224	1593413632	34·1760150	10·5312749	·0008561644
1169	1366561	1597509809	34·1906420	10·5342795	·0008554320
1170	1368900	1601613000	34·2052627	10·5372825	·0008547009
1171	1371241	1605723211	34·2198773	10·5402837	·0008539710
1172	1373584	1609840448	34·2344855	10·5432832	·0008532423

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1173	1375929	1613964717	34·2490875	10·5462810	·0008525149
1174	1378276	1618096024	34·2636834	10·5492771	·0008517888
1175	1380625	1622234375	34·2782730	10·5522715	·0008510638
1176	1382976	1626379776	34·2928564	10·5552642	·0008503401
1177	1385329	1630532233	34·3074336	10·5582552	·0008496177
1178	1387684	1634691752	34·3220046	10·5612445	·0008488964
1179	1390041	1638858339	34·3365694	10·5642322	·0008481764
1180	1392400	1643032000	34·3511281	10·5672181	·0008474576
1181	1394761	1647212741	34·3656805	10·5702024	·0008467401
1182	1397124	1651400568	34·3802268	10·5731849	·0008460237
1183	1399489	1655595487	34·3947670	10·5761658	·0008453085
1184	1401856	1659797504	34·4093011	10·5791449	·0008445946
1185	1404225	1664006625	34·4238289	10·5821225	·0008438819
1186	1406596	1668222856	34·4383507	10·5850983	·0008431703
1187	1408969	1672446203	34·4528663	10·5880725	·0008424600
1188	1411344	1676676672	34·4673759	10·5910450	·0008417508
1189	1413721	1680914269	34·4818793	10·5940158	·0008410429
1190	1416100	1685159000	34·4963766	10·5969850	·0008403361
1191	1418481	1689410871	34·5108678	10·5999525	·0008396306
1192	1420864	1693669888	34·5253530	10·6029184	·0008389262
1193	1423249	1697936057	34·5398321	10·6058826	·0008382230
1194	1425636	1702209384	34·5543051	10·6088451	·0008375209
1195	1428025	1706489875	34·5687720	10·6118060	·0008368201
1196	1430416	1710777536	34·5832329	10·6147652	·0008361204
1197	1432809	1715072373	34·5976879	10·6177228	·0008354219
1198	1435204	1719374392	34·6121366	10·6206788	·0008347245
1199	1437601	1723683599	34·6265794	10·6236331	·0008340284
1200	1440000	1728000000	34·6410162	10·6265857	·0008333333
1201	1442401	1732323601	34·6554469	10·6295367	·0008326395
1202	1444804	1736654408	34·6698716	10·6324860	·0008319468
1203	1447209	1740992427	34·6842904	10·6354338	·0008312552
1204	1449616	1745337664	34·6987031	10·6383799	·0008305648
1205	1452025	1749690125	34·7131099	10·6413244	·0008298755
1206	1454436	1754049816	34·7275107	10·6442672	·0008291874
1207	1456849	1758416743	34·7419055	10·6472085	·0008285004
1208	1459264	1762790912	34·7562944	10·6501480	·0008278146
1209	1461681	1767172329	34·7706773	10·6530860	·0008271299
1210	1464100	1771561000	34·7850543	10·6560223	·0008264463
1211	1466521	1775956931	34·7994253	10·6589570	·0008257638
1212	1468944	1780360128	34·8137904	10·6618902	·0008250825
1213	1471369	1784770597	34·8281495	10·6648217	·0008244023
1214	1473796	1789188344	34·8425028	10·6677516	·0008237232
1215	1476225	1793613375	34·8568501	10·6706799	·0008230453
1216	1478656	1798045696	34·8711915	10·6736066	·0008223684
1217	1481089	1802485313	34·8855271	10·6765317	·0008216927
1218	1483524	1806932232	34·8998567	10·6794552	·0008210181
1219	1485961	1811386459	34·9141805	10·6823771	·0008203445
1220	1488400	1815848000	34·9284984	10·6852973	·0008196721
1221	1490841	1820316861	34·9428104	10·6882160	·0008190008

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1222	1493284	1824793048	34·9571166	10·6911831	·0008183306
1223	1495729	1829276567	34·9714169	10·6940486	·0008176615
1224	1498176	1833767424	34·9857114	10·6969625	·0008169935
1225	1500625	1838265625	35·0000000	10·6998748	·0008163265
1226	1503076	1842771176	35·0142828	10·7027855	·0008156607
1227	1505529	1847284083	35·0285598	10·7056947	·0008149959
1228	1507984	1851804352	35·0428309	10·7086023	·0008143322
1229	1510441	1856331989	35·0570963	10·7115083	·0008136696
1230	1512900	1860867000	35·0713558	10·7144127	·0008130081
1231	1515361	1865409391	35·0856096	10·7173155	·0008123477
1232	1517824	1869959168	35·0998575	10·7202168	·0008116883
1233	1520289	1874516337	35·1140997	10·7231165	·0008110300
1234	1522756	1879080904	35·1283361	10·7260146	·0008103728
1235	1525225	1883652875	35·1425668	10·7289112	·0008097166
1236	1527696	1888232256	35·1567917	10·7318062	·0008090615
1237	1530169	1892819053	35·1710108	10·7346997	·0008084074
1238	1532644	1897413272	35·1852242	10·7375916	·0008077544
1239	1535121	1902014919	35·1994318	10·7404819	·0008071025
1240	1537600	1906624000	35·2136337	10·7433707	·0008064516
1241	1540081	1911240521	35·2278299	10·7462579	·0008058018
1242	1542564	1915864488	35·2420204	10·7491436	·0008051530
1243	1545049	1920495907	35·2562051	10·7520277	·0008045052
1244	1547536	1925134784	35·2703842	10·8549103	·0008038585
1245	1550025	1929781125	35·2845575	10·7577913	·0008032129
1246	1552516	1934434936	35·2987252	10·7606708	·0008025682
1247	1555009	1939096223	35·3128872	10·7635488	·0008019246
1248	1557504	1943764992	35·3270435	10·7664252	·0008012821
1249	1560001	1948441249	35·3411941	10·7693001	·0008006405
1250	1562500	1953125000	35·3553391	10·7721735	·0008000000
1251	1565001	1957816251	35·3694784	10·7750453	·0007993605
1252	1567504	1962515008	35·3836120	10·7779156	·0007987220
1253	1570009	1967221277	35·3977400	10·7807843	·0007980846
1254	1572516	1971935064	35·4118624	10·7836516	·0007974482
1255	1575025	1976656375	35·4259792	10·7865173	·0007968127
1256	1577536	1981385216	35·4400903	10·7893815	·0007961783
1257	1580049	1986121593	35·4541958	10·7922441	·0007955449
1258	1582564	1990865512	35·4682957	10·7951053	·0007949126
1259	1585081	1995616979	35·4823900	10·7979649	·0007942812
1260	1587600	2000376000	35·4964787	10·8008230	·0007936508
1261	1590121	2005142581	35·5105618	10·8036797	·0007930214
1262	1592644	2009916728	35·5246393	10·8065348	·0007923930
1263	1595169	2014698447	35·5387113	10·8093884	·0007917656
1264	1597696	2019487744	35·5527777	10·8122404	·0007911392
1265	1600225	2024284625	35·5668385	10·8150909	·0007905138
1266	1602756	2029089096	35·5808937	10·8179400	·0007898894
1267	1605289	2033901163	35·5949434	10·8207876	·0007892660
1268	1607824	2038720832	35·6089876	10·8236336	·0007886435
1269	1610361	2043548109	35·6230262	10·8264782	·0007880221
1270	1612900	2048383000	35·6370593	10·8293213	·0007874016

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1271	1615441	2053225511	35·6510869	10·8321629	·0007867821
1272	1617984	2058075648	35·6651090	10·8350030	·0007861635
1273	1620529	2062933417	35·6791255	10·8378416	·0007855460
1274	1623076	2067798824	35·6931366	10·8406788	·0007849294
1275	1625625	2072671875	35·7071421	10·8435144	·0007843137
1276	1628176	2077552576	35·7211422	10·8463485	·0007836991
1277	1630729	2082440933	35·7351367	10·8491812	·0007830854
1278	1633284	2087336952	35·7491258	10·8520125	·0007824726
1279	1635841	2092240639	35·7631095	10·8548422	·0007818608
1280	1638400	2097152000	35·7770876	10·8576704	·0007812500
1281	1640961	2102071041	35·7910603	10·8604972	·0007806401
1282	1643524	2106997768	35·8050276	10·8633225	·0007800312
1283	1646089	2111932187	35·8189894	10·8661464	·0007794232
1284	1648656	2116874304	35·8329457	10·8689687	·0007788162
1285	1651225	2121824125	35·8468966	10·8717897	·0007782101
1286	1653796	2126781656	35·8608421	10·8746091	·0007776050
1287	1656369	2131746903	35·8747822	10·8774271	·0007770008
1288	1658944	2136719872	35·8887169	10·8802436	·0007763975
1289	1661521	2141700569	35·9026461	10·8830587	·0007757952
1290	1664100	2146689000	35·9165699	10·8858723	·0007751938
1291	1666681	2151685171	35·9304884	10·8886845	·0007745933
1292	1669264	2156689088	35·9444015	10·8914952	·0007739938
1293	1671849	2161700757	35·9583092	10·8943044	·0007733952
1294	1674436	2166720184	35·9722115	10·8971123	·0007727975
1295	1677025	2171747375	35·9861084	10·8999186	·0007722008
1296	1679616	2176782336	36·0000000	10·9027235	·0007716049
1297	1682209	2181825073	36·0138862	10·9055269	·0007710100
1298	1684804	2186875592	36·0277671	10·9083290	·0007704160
1299	1687401	2191933899	36·0416426	10·9111296	·0007698229
1300	1690000	2197000000	36·0555128	10·9139287	·0007692308
1301	1692601	2202073901	36·0693776	10·9167265	·0007686395
1302	1695204	2207155608	36·0832371	10·9195228	·0007680492
1303	1697809	2212245127	36·0970913	10·9223177	·0007674597
1304	1700416	2217342464	36·1109402	10·9251111	·0007668712
1305	1703025	2222447625	36·1247837	10·9279031	·0007662835
1306	1705636	2227560616	36·1386220	10·9306937	·0007656968
1307	1708249	2232681443	36·1524550	10·9334829	·0007651109
1308	1710864	2237810112	36·1662826	10·9362706	·0007645260
1309	1713481	2242946629	36·1801050	10·9390569	·0007639419
1310	1716100	2248091000	36·1939221	10·9418418	·0007633588
1311	1718721	2253243231	36·2077340	10·9446253	·0007627765
1312	1721344	2258403328	36·2215406	10·9474074	·0007621951
1313	1723969	2263571297	36·2353419	10·9501880	·0007616146
1314	1726596	2268747144	36·2491379	10·9529673	·0007610350
1315	1729225	2273930875	36·2629287	10·9557451	·0007604563
1316	1731856	2279122496	36·2767143	10·9585215	·0007598784
1317	1734489	2284322013	36·2904946	10·9612965	·0007593014
1318	1737124	2289529432	36·3042697	10·9640701	·0007587253
1319	1739761	2294744759	36·3180396	10·9668423	·0007581501

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1320	1742400	2299968000	36·3318042	10·9696131	·0007575758
1321	1745041	2305199161	36·3455637	10·9723825	·0007570023
1322	1747684	2310438248	36·3593179	10·9751505	·0007564297
1323	1750329	2315685267	36·3730670	10·9779171	·0007558579
1324	1752976	2320940224	36·3868108	10·9806823	·0007552870
1325	1755625	2326203125	36·4005494	10·9834462	·0007547170
1326	1758276	2331473976	36·4142829	10·9862086	·0007541478
1327	1760929	2336752783	36·4280112	10·9889696	·0007535795
1328	1763584	2342039552	36·4417343	10·9917293	·0007530120
1329	1766241	2347334289	36·4554523	10·9944876	·0007524454
1330	1768900	2352637000	36·4691650	10·9972445	·0007518797
1331	1771561	2357947691	36·4828727	11·0000000	·0007513148
1332	1774224	2363266368	36·4965752	11·0027541	·0007507508
1333	1776889	2368593037	36·5102725	11·0055069	·0007501875
1334	1779556	2373927704	36·5239647	11·0082583	·0007496252
1335	1782225	2379270375	36·5376518	11·0110082	·0007490637
1336	1784896	2384621056	36·5513338	11·0137569	·0007485030
1337	1787569	2389979753	36·5650106	11·0165041	·0007479432
1338	1790244	2395346472	36·5786823	11·0192500	·0007473842
1339	1792921	2400721219	36·5923489	11·0219945	·0007468260
1340	1795600	2406104000	36·6060104	11·0247377	·0007462687
1341	1798281	2411494821	36·6196668	11·0274795	·0007457122
1342	1800964	2416893688	36·6333181	11·0302199	·0007451565
1343	1803649	2422300607	36·6469644	11·0329590	·0007446016
1344	1806336	2427715584	36·6606056	11·0356967	·0007440476
1345	1809025	2433138625	36·6742416	11·0384330	·0007434944
1346	1811716	2438569736	36·6878726	11·0411680	·0007429421
1347	1814409	2444008923	36·7014986	11·0439017	·0007423905
1348	1817104	2449456192	36·7151195	11·0466339	·0007418398
1349	1819801	2454911549	36·7287353	11·0493649	·0007412898
1350	1822500	2460375000	36·7423461	11·0520945	·0007407407
1351	1825201	2465846551	36·7559519	11·0548227	·0007401924
1352	1827904	2471326208	36·7695526	11·0575497	·0007396450
1353	1830609	2476813977	36·7831483	11·0602752	·0007390983
1354	1833316	2482309864	36·7967390	11·0629994	·0007385524
1355	1836025	2487813875	36·8103246	11·0657222	·0007380074
1356	1838736	2493326016	36·8239053	11·0684437	·0007374631
1357	1841449	2498846293	36·8374809	11·0711639	·0007369197
1358	1844164	2504374712	36·8510515	11·0738828	·0007363770
1359	1846881	2509911279	36·8646172	11·0766003	·0007358352
1360	1849600	2515456000	36·8781778	11·0793165	·0007352941
1361	1852321	2521008881	36·8917335	11·0820314	·0007347539
1362	1855044	2526569928	36·9052842	11·0847449	·0007342144
1363	1857769	2532139147	36·9188299	11·0874571	·0007336757
1364	1860496	2537716544	36·9323706	11·0901679	·0007331378
1365	1863225	2543302125	36·9459064	11·0928775	·0007326007
1366	1865956	2548895896	36·9594372	11·0955857	·0007320644
1367	1868689	2554497863	36·9729631	11·0982926	·0007315289
1368	1871424	2560108032	36·9864840	11·1009982	·0007309942

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1369	1874161	2565726409	37·0000000	11·1037025	·0007304602
1370	1876900	2571353000	37·0135110	11·1064054	·0007299270
1371	1879641	2576987811	37·0270172	11·1091070	·0007293946
1372	1882384	2582630848	37·0405184	11·1118073	·0007288630
1373	1885129	2588282117	37·0540146	11·1145064	·0007283321
1374	1887876	2593941624	37·0675060	11·1172041	·0007278020
1375	1890625	2599609375	37·0809924	11·1199004	·0007272727
1376	1893376	2605285376	37·0944740	11·1225955	·0007267442
1377	1896129	2610969633	37·1079506	11·1252893	·0007262164
1378	1898884	2616662152	37·1214224	11·1279817	·0007256894
1379	1901641	2622362939	37·1348893	11·1306729	·0007251632
1380	1904400	2628072000	37·1483512	11·1333628	·0007246377
1381	1907161	2633789341	37·1618084	11·1360514	·0007241130
1382	1909924	2639514968	37·1752606	11·1387386	·0007235890
1383	1912689	2645248887	37·1887079	11·1414246	·0007230658
1384	1915456	2650991104	37·2021505	11·1441093	·0007225434
1385	1918225	2656741625	37·2155881	11·1467926	·0007220217
1386	1920996	2662500456	37·2290209	11·1494747	·0007215007
1387	1923769	2668267603	37·2424489	11·1521555	·0007209805
1388	1926544	2674043072	37·2558720	11·1548350	·0007204611
1389	1929321	2679826869	37·2692903	11·1575133	·0007199424
1390	1932100	2685619000	37·2827037	11·1601903	·0007194245
1391	1934881	2691419471	37·2961124	11·1628659	·0007189073
1392	1937664	2697228288	37·3095162	11·1655403	·0007183908
1393	1940449	2703045457	37·3229152	11·1682134	·0007178751
1394	1943236	2708870984	37·3363094	11·1708852	·0007173601
1395	1946025	2714704875	37·3496988	11·1735558	·0007168459
1396	1948816	2720547136	37·3630834	11·1762250	·0007163324
1397	1951609	2726397773	37·3764632	11·1788930	·0007158196
1398	1954404	2732256792	37·3898382	11·1815598	·0007153076
1399	1957201	2738124199	37·4032084	11·1842252	·0007147963
1400	1960000	2744000000	37·4165738	11·1868894	·0007142857
1401	1962801	2749884201	37·4299345	11·1895523	·0007137759
1402	1965604	2755776808	37·4432904	11·1922139	·0007132668
1403	1968409	2761677827	37·4566416	11·1948743	·0007127584
1404	1971216	2767587264	37·4699880	11·1975334	0007122507
1405	1974025	2773505125	37·4833296	11·2001913	·0007117438
1406	1976836	2779431416	37·4966665	11·2028479	·0007112376
1407	1979649	2785366143	37·5099987	11·2055032	·0007107321
1408	1982464	2791309312	37·5233261	11·2081573	·0007102273
1409	1985281	2797260929	37·5366487	11·2108101	·0007097232
1410	1988100	2803221000	37·5499667	11·2134617	·0007092199
1411	1990921	2809189531	37·5632799	11·2161120	·0007087172
1412	1993744	2815166528	37·5765885	11·2187611	·0007082153
1413	1996569	2821151997	37·5898922	11·2214089	·0007077141
1414	1999396	2827145944	37·6031913	11·2240554	·0007072136
1415	2002225	2833148375	37·6164857	11·2267007	·0007067138
1416	2005056	2839159296	37·6297754	11·2293448	·0007062147
1417	2007889	2845178713	37·6430604	11·2319876	·0007057163

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1418	2010724	2851206632	37·6563407	11·2346292	·0007052186
1419	2013561	2857243059	37·6696164	11·2372696	·0007047216
1420	2016400	2863288000	37·6828874	11·2399087	·0007042254
1421	2019241	2869341461	37·6961536	11·2425465	·0007037298
1422	2022084	2875403448	37·7094153	11·2451831	·0007032349
1423	2024929	2881473967	37·7226722	11·2478185	·0007027407
1424	2027776	2887553024	37·7359245	11·2504527	·0007022472
1425	2030625	2893640625	37·7491722	11·2530856	·0007017544
1426	2033476	2899736776	37·7624152	11·2557173	·0007012623
1427	2036329	2905841483	37·7756535	11·2583478	·0007007708
1428	2039184	2911954752	37·7888873	11·2609770	·0007002801
1429	2042041	2918076589	37·8021163	11·2636050	·0006997901
1430	2044900	2924207000	37·8153408	11·2662318	·0006993007
1431	2047761	2930345991	37·8285606	11·2688573	·0006988120
1432	2050624	2936493568	37·8417759	11·2714816	·0006983240
1433	2053489	2942649737	37·8549864	11·2741047	·0006978367
1434	2056356	2948814504	37·8681924	11·2767266	·0006973501
1435	2059225	2954987875	37·8813938	11·2793472	·0006968641
1436	2062096	2961169856	37·8945906	11·2819666	·0006963788
1437	2064969	2967360453	37·9077828	11·2845849	·0006958942
1438	2067844	2973559672	37·9209704	11·2872019	·0006954103
1439	2070721	2979767519	37·9341535	11·2898177	·0006949270
1440	2073600	2985984000	37·9473319	11·2924323	·0006944444
1441	2076481	2992209121	37·9605058	11·2950457	·0006939625
1442	2079364	2998442888	37·9736751	11·2976579	·0006934813
1443	2082249	3004685307	37·9868398	11·3002688	·0006930007
1444	2085136	3010936384	38·0000000	11·3028786	·0006925208
1445	2088025	3017196125	38·0131556	11·3054871	·0006920415
1446	2090916	3023464536	38·0263067	11·3080945	·0006915629
1447	2093809	3029741623	38·0394532	11·3107006	·0006910850
1448	2096704	3036027392	38·0525952	11·3133056	·0006906078
1449	2099601	3042321849	38·0657326	11·3159094	·0006901312
1450	2102500	3048625000	38·0788655	11·3185119	·0006896552
1451	2105401	3054936851	38·0919939	11·3211132	·0006891799
1452	2108304	3061257408	38·1051178	11·3237134	·0006887052
1453	2111209	3067586677	38·1182371	11·3263124	·0006882312
1454	2114116	3073924664	38·1313519	11·3289102	·0006877579
1455	2117025	3080271375	38·1444622	11·3315067	·0006872852
1456	2119936	3086626816	38·1575681	11·3341022	·0006868132
1457	2122849	3092990993	38·1706693	11·3366964	·0006863418
1458	2125764	3099363912	38·1837662	11·3392894	·0006858711
1459	2128681	3105745579	38·1968585	11·3418813	·0006854010
1460	2131600	3112136000	38·2099463	11·3444719	·0006849315
1461	2134521	3118535181	38·2230297	11·3470614	·0006844627
1462	2137444	3124943128	38·2361085	11·3496497	·0006839945
1463	2140369	3131359847	38·2491829	11·3522368	·0006835270
1464	2143296	3137785344	38·2622529	11·3548227	·0006830601
1465	2146225	3144219625	38·2753184	11·3574075	·0006825939
1466	2149156	3150662696	38·2883794	11·3599911	·0006821282

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1467	2152089	3157114563	38·3014360	11·3625735	·0006816633
1468	2155024	3163575232	38·3144881	11·3651547	·0006811989
1469	2157961	3170044709	38·3275358	11·3677347	·0006807352
1470	2160900	3176523000	38·3405790	11·3703136	·0006802721
1471	2163841	3183010111	38·3536178	11·3728914	·0006798097
1472	2166784	3189506048	38·3666522	11·3754679	·0006793478
1473	2169729	3169010817	38·3796821	11·3780433	·0006788866
1474	2172676	3202524424	38·3927076	11·3806175	·0006784261
1475	2175625	3209046875	38·4057287	11·3831906	·0006779661
1476	2178576	3215578176	38·4187454	11·3857625	·0006775068
1477	2181529	3222118333	38·4317577	11·3883332	·0006770481
1478	2184484	3228667352	38·4447656	11·3909028	·0006765900
1479	2187441	3235225239	38·4577691	11·3934712	·0006761325
1480	2190400	3241792000	38·4707681	11·3960384	·0006756757
1481	2193361	3248367641	38·4837627	11·3986045	·0006752194
1482	2196324	3254952168	38·4967530	11·4011695	·0006747638
1483	2199289	3261545587	38·5097390	11·4037332	·0006743088
1484	2202256	3268147904	38·5227206	11·4062959	·0006738544
1485	2205225	3274759125	38·5356977	11·4088574	·0006734007
1486	2208196	3281379256	38·5486705	11·4114177	·0006729475
1487	2211169	3288008303	38·5616389	11·4139769	·0006724950
1488	2214144	3294646272	38·5746030	11·4165349	·0006720430
1489	2217121	3301293169	38·5875627	11·4190918	·0006715917
1490	2220100	3307949000	38·6005181	11·4216476	·0006711409
1491	2223081	3314613771	38·6134691	11·4242022	·0006706908
1492	2226064	3321287488	38·6264158	11·4267556	·0006702413
1493	2229049	3327970157	38·6393582	11·4293079	·0006697924
1494	2232036	3334661784	38·6522962	11·4318591	·0006693440
1495	2235025	3341362375	38·6652299	11·4344092	·0006688963
1496	2238016	3348071936	38·6781593	11·4369581	·0006684492
1497	2241009	3354790473	38·6910843	11·4395059	·0006680027
1498	2244004	3361517992	38·7040050	11·4420525	·0006675567
1499	2247001	3368254499	38·7169214	11·4445980	·0006671114
1500	2250000	3375000000	38·7298335	11·4471424	·0006666667
1501	2253001	3381754501	38·7427412	11·4496857	·0006662225
1502	2256004	3388518008	38·7556447	11·4522278	·0006657790
1503	2259009	3395290527	38·7685439	11·4547688	·0006643360
1504	2262016	3402072064	38·7814389	11·4573087	·0006648936
1505	2265025	3408862625	38·7943294	11·4598474	·0006644518
1506	2268036	3415662216	38·8072158	11·4623850	·0006640106
1507	2271049	3422470843	38·8200978	11·4649215	·0006635700
1508	2274064	3429288512	38·8329757	11·4674568	·0006631300
1509	2277081	3436115229	38·8458491	11·4699911	·0006626905
1510	2280100	3442951000	38·8587184	11·4725242	·0006622517
1511	2283121	3449795831	38·8715834	11·4750562	·0006618134
1512	2286144	3456649728	38·8844442	11·4775871	·0006613757
1513	2289169	3463512697	38·8973006	11·4801169	·0006609385
1514	2292196	3470384744	38·9101529	11·4826455	·0006605020
1515	2295225	3477265875	38·9230009	11·4851731	·0006600660

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1516	2298256	3484156096	38·9358447	11·4876995	·0006596306
1517	2301289	3491055413	38·9486841	11·4902249	·0006591958
1518	2304324	3497963832	98·9615194	11·4927491	·0006587615
1519	2307361	3504881359	38·9743505	11·4952722	·0006583278
1520	2310400	3511808000	38·9871774	11·4977942	·0006578947
1521	2313441	3518743761	39·0000000	11·5003151	·0006574622
1522	2316484	3525688648	39·0128184	11·5028348	·0006570302
1523	2319529	3532642667	39·0256326	11·5053535	·0006565988
1524	2322576	3539605824	39·0384426	11·5078711	·0006561680
1525	2325625	3546578125	39·0512483	11·5103876	·0006557377
1526	2328676	3553559576	39·0640499	11·5129030	·0006553080
1527	2331729	3560550183	39·0768473	11·5154173	·0006548788
1528	2334784	3567549952	39·0896406	11·5179305	·0006544503
1529	2337841	3574558889	39·1024296	11·5204425	·0006540222
1530	2340900	3581577000	39·1152144	11·5229535	·0006535948
1531	2343961	3588604291	39·1279951	11·5254634	·0006531679
1532	2347024	3595640768	39·1407716	11·5279722	·0006527415
1533	2350089	3602686437	39·1535439	11·5304799	·0006523157
1534	2353156	3609741304	39·1663120	11·5329865	·0006518905
1535	2356225	3616805375	39·1790760	11·5354920	·0006514658
1536	2359296	3623878656	39·1918359	11·5379965	·0006510417
1537	2362369	3630961153	39·2045915	11·5404998	·0006506181
1538	2365444	3638052872	39·2173431	11·5430021	·0006501951
1539	2368521	3645153819	39·2300905	11·5455033	·0006497726
1540	2371600	3652264000	39·2428337	11·5480034	·0006493506
1541	2374681	3659383421	39·2555728	11·5505025	·0006489293
1542	2377764	3666512088	39·2683078	11·5530004	·0006485084
1543	2380849	3673650007	39·2810387	11·5554973	·0006480881
1544	2383936	3680797184	39·2937654	11·5579931	·0006476684
1545	2387025	3687953625	39·3064880	11·5604878	·0006472492
1546	2390116	3695119336	39·3192065	11·5629815	·0006468305
1547	2393209	3702294323	39·3319208	11·5654740	·0006464124
1548	2396304	3709478592	39·3446311	11·5679655	·0006459948
1549	2399401	3716672149	39·3573373	11·5704559	·0006455778
1550	2402500	3723875000	39·3700394	11·5729453	·0006451613
1551	2405601	3731087151	39·3827373	11·5754336	·0006447453
1552	2408704	3738308608	39·3954312	11·5779208	·0006443299
1553	2411809	3745539377	39·4081210	11·5804069	·0006439150
1554	2414916	3752779464	39·4208067	11·5828919	0006435006
1555	2418025	3760028875	39·4334883	11·5853759	·0006430868
1556	2421136	3767287616	39·4461658	11·5878588	·0006426735
1557	2424249	3774555693	39·4588393	11·5903407	·0006422608
1558	2427364	3781833112	39·4715087	11·5928215	·0006418485
1559	2430481	3789119879	39·4841740	11·5953013	·0006414368
1560	2433600	3796416000	39·4968353	11·5977799	·0006410256
1561	2436721	3803721481	39·5094925	11·6002576	·0006406150
1562	2439844	3811036328	39·5221457	11·6027342	·0006402049
1563	2442969	3818360547	39·5347948	11·6052097	·0006397953
1564	2446096	3825694144	39·5474399	11·6076841	·0006393862

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1565	2449225	3833037125	39·5600809	11·6101575	·0006389776
1566	2452356	3840389496	39·5727179	11·6126299	·0006385696
1567	2455489	3847751263	39·5853508	11·6151012	·0006381621
1568	2458624	3855122432	39·5979797	11·6175715	·0006377551
1569	2461761	3862503009	39·6106046	11·6200407	·0006373486
1570	2464900	3869893000	39·6232255	11·6225088	·0006369427
1571	2468041	3877292411	39·6358424	11·6249759	·0006365372
1572	2471184	3884701248	39·6484552	11·6274420	·0006361323
1573	2474329	3892119517	39·6610640	11·6299070	·0006357279
1574	2477476	3899547224	39·6736688	11·6323710	·0006353240
1575	2480625	3906984375	39·6862696	11·6348339	·0006349206
1576	2483776	3914430976	39·6988665	11·6372957	·0006345178
1577	2486929	3921887033	39·7114593	11·6397566	·0006341154
1578	2490084	3929352552	39·7240481	11·6422164	·0006337136
1579	2493241	3936827539	39·7366329	11·6446751	·0006333122
1580	2496400	3944312000	39·7492138	11·6471329	·0006329114
1581	2499561	3951805941	39·7617907	11·6495895	·0006325111
1582	2502724	3959309368	39·7743636	11·6520452	·0006321113
1583	2505889	3966822287	39·7869325	11·6544998	·0006317119
1584	2509056	3974344704	39·7994975	11·6569534	·0006313131
1585	2512225	3981876625	39·8120585	11·6594059	·0006309148
1586	2515396	3989418056	39·8246155	11·6618574	·0006305170
1587	2518569	3996969003	39·8371686	11·6643079	·0006301197
1588	2521744	4004529472	39·8497177	11·6667574	·0006297229
1589	2524921	4012099469	39·8622628	11·6692058	·0006293266
1590	2528100	4019679000	39·8748040	11·6716532	·0006289308
1591	2531281	4027268071	39·8873413	11·6740996	·0006285355
1592	2534464	4034866688	39·8998747	11·6765449	·0006281407
1593	2537649	4042474857	39·9124041	11·6789892	·0006277464
1594	2540836	4050092584	39·9249295	11·6814325	·0006273526
1595	2544025	4057719875	39·9374511	11·6838748	·0006269592
1596	2547216	4065356736	39·9499687	11·6863161	·0006265664
1597	2550409	4073003173	39·9624824	11·6887563	·0006261741
1598	2553604	4080659192	39·9749922	11·6911955	·0006257822
1599	2556801	4088324799	39·9874980	11·6936337	·0006253909
1600	2560000	4096000000	40·0000000	11·6960709	·0006250000
1601	2563201	4103684801	40·0124980	11·6985071	·0006246096
1602	2566404	4111379208	40·0249922	11·7009422	·0006242197
1603	2569609	4119083227	40·0374824	11·7033764	·0006238303
1604	2572816	4126796864	40·0499688	11·7058095	·0006234414
1605	2576025	4134520125	40·0624512	11·7082417	·0006230530
1606	2579236	4142253016	40·0749298	11·7106728	·0006226650
1607	2582449	4149995543	40·0874045	11·7131029	·0006222775
1608	2585664	4157747712	40·0998753	11·7155320	·0006218905
1609	2588881	4165509529	40·1123423	11·7179601	·0006215040
1610	2592100	4173281000	40·1248053	11·7203872	·0006211180
1611	2595321	4181062131	40·1372645	11·7228133	·0006207325
1612	2598544	4188852928	40·1497198	11·7252384	·0006203474
1613	2601769	4196653397	40·1621713	11·7276625	·0006199628

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1614	2604996	4204463544	40·1746188	11·7300855	·0006195787
1615	2608225	4212283375	40·1870626	11·7325076	·0006191950
1616	2611456	4220112896	40·1995025	11·7349286	·0006188119
1617	2614689	4227952113	40·2119385	11·7373487	·0006184292
1618	2617924	4235801032	40·2243707	11·7397677	·0006180470
1619	2621161	4243659659	40·2367990	11·7421858	·0006176652
1620	2624400	4251528000	40·2492236	11·7446029	·0006172840
1621	2627641	4259406061	40·2616443	11·7470190	·0006169031
1622	2630884	4267293848	40·2740611	11·7494341	·0006165228
1623	2634129	4275191367	40·2864742	11·7518482	·0006161429
1624	2637376	4283098624	40·2988834	11·7542613	·0006157635
1625	2640625	4291015625	40·3112888	11·7566734	·0006153846
1626	2643876	4298942376	40·3236903	11·7590846	·0006150062
1627	2647129	4306878883	40·3360881	11·7614947	·0006146282
1628	2650384	4314825152	40·3484820	11·7639039	·0006142506
1629	2653641	4322781189	40·3608721	11·7663121	·0006138735
1630	2656900	4330747000	40·3732585	11·7687193	·0006134969
1631	2660161	4338722591	40·3856410	11·7711255	·0006131208
1632	2663424	4346707968	40·3980198	11·7735306	·0006127451
1633	2666689	4354703137	40·4103947	11·7759349	·0006123699
1634	2669956	4362708104	40·4227658	11·7783381	·0006119951
1635	2673225	4370722875	40·4351332	11·7807404	·0006116208
1636	2676496	4378747456	40·4474968	11·7831417	·0006112469
1637	2679769	4386781853	40·4598566	11·7855420	·0006108735
1638	2683044	4394826072	40·4722127	11·7879414	·0006105006
1639	2686321	4402880119	40·4845649	11·7903397	·0006101281
1640	2689600	4410944000	40·4969135	11·7927371	·0006097561
1641	2692881	4419017721	40·5092582	11·7951335	·0006093845
1642	2696164	4427101288	40·5215992	11·7975289	·0006090134
1643	2699449	4435194707	40·5339364	11·7999234	·0006086427
1644	2702736	4443297984	40·5462699	11·8023169	·0006082725
1645	2706025	4451411125	40·5585996	11·8047094	·0006079027
1646	2709316	4459534136	40·5709255	11·8071010	·0006075334
1647	2712609	4467667023	40·5832477	11·8094916	·0006071645
1648	2715904	4475809792	40·5955663	11·8118812	·0006067961
1649	2719201	4483962449	40·6078810	11·8142698	·0006064281
1650	2722500	4492125000	40·6201920	11·8166576	·0006060606
1651	2725801	4500297451	40·6324993	11·8190443	·0006056935
1652	2729104	4508479808	40·6448029	11·8214301	·0006053269
1653	2732409	4516672077	40·6571027	11·8238149	·0006049607
1654	2735716	4524874264	40·6693988	11·8261987	·0006045949
1655	2739025	4533086375	40·6816912	11·8285816	·0006042296
1656	2742336	4541308416	40·6939799	11·8309634	·0006038647
1657	2745649	4549540393	40·7062648	11·8333444	·0006035003
1658	2748964	4557782312	40·7185461	11·8357244	·0006031363
1659	2752281	4566034179	40·7308237	11·8381034	·0006027728
1660	2755600	4574296000	40·7430976	11·8404815	·0006024096
1661	2758921	4582567781	40·7553677	11·8428586	·0006020470
1662	2762244	4590849528	40·7676342	11·8452348	·0006016847

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1663	2765569	4599141247	40·7798970	11·8476100	·0006013229
1664	2768896	4607442994	40·7921561	11·8499843	·0006009615
1665	2772225	4615754625	40·8044115	11·8523576	·0006006006
1666	2775556	4624076296	40·8166633	11·8547299	·0006002401
1667	2778889	4632407963	40·8289113	11·8571014	·0005998800
1668	2782224	4640749632	40·8411557	11·8594719	·0005995204
1669	2785561	4649101309	40·8533964	11·8618414	·0005991612
1670	2788900	4657463000	40·8656335	11·8642100	·0005988024
1671	2792241	4665834711	40·8778669	11·8665776	·0005984440
1672	2795584	4674216448	40·8900966	11·8689443	·0005980861
1673	2798929	4682608217	40·9023227	11·8713100	·0005977286
1674	2802276	4691010024	40·9145451	11·8736748	·0005973716
1675	2805625	4699421875	40·9267638	11·8760387	·0005970149
1676	2808976	4707843776	40·9389790	11·8784016	·0005966587
1677	2812329	4716275733	40·9511905	11·8807636	·0005963029
1678	2815684	4724717752	40·9633983	11·8831246	·0005959476
1679	2819041	4733169839	40·9756025	11·8854847	·0005955926
1680	2822400	4741632000	40·9878031	11·8878439	·0005952381
1681	2825761	4750104241	41·0000000	11·8902022	·0005948840
1682	2829124	4758586568	41·0121933	11·8925595	·0005945303
1683	2832489	4767078987	41·0243830	11·8949159	·0005941771
1684	2835856	4775581504	41·0365691	11·8972713	·0005938242
1685	2839225	4784094125	41·0487515	11·8996258	·0005934718
1686	2842596	4792616856	41·0609303	11·9019793	·0005931198
1687	2845969	4801149703	41·0731055	11·9043319	·0005927682
1688	2849344	4809692672	41·0852772	11·9066836	·0005924171
1689	2852721	4818245769	41·0974452	11·9090344	·0005920663
1690	2856100	4826809000	41·1096096	11·9113843	·0005917160
1691	2859481	4835382371	41·1217704	11·9137332	·0005913661
1692	2862864	4843965888	41·1339276	11·9160812	·0005910165
1693	2866249	4852559557	41·1460812	11·9184283	·0005906675
1694	2869636	4861163384	41·1582313	11·9207744	·0005903188
1695	2873025	4869777375	41·1703777	11·9231196	·0005899705
1696	2876416	4878401536	41·1825206	11·9254639	·0005896226
1697	2879809	4887035873	41·1946599	11·9278073	·0005892752
1698	2883204	4895680392	41·2067956	11·9301497	·0005889282
1699	2886601	4904335099	41·2189277	11·9324913	·0005885815
1700	2890000	4913000000	41·2310563	11·9348319	·0005882353
1701	2893401	4921675101	41·2431812	11·9371716	·0005878895
1702	2896804	4930360408	41·2553027	11·9395104	·0005875441
1703	2900209	4939055927	41·2674205	11·9418482	·0005871991
1704	2903616	4947761664	41·2795349	11·9441852	·0005868545
1705	2907025	4956477625	41·2916456	11·9465213	·0005865103
1706	2910436	4965203816	41·3037529	11·9488564	·0005861665
1707	2913849	4973940243	41·3158565	11·9511906	·0005858231
1708	2917264	4982686912	41·3279566	11·9535239	·0005854801
1709	2920681	4991443829	41·3400532	11·9558563	·0005851375
1710	2924100	5000211000	41·3521463	11·9581878	·0005847953
1711	2927521	5008988431	41·3642358	11·9605184	·0005844535

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1712	2930944	5017776128	41·3763217	11·9628481	·0005841121
1713	2934369	5026574097	41·3884042	11·9651768	·0005837712
1714	2937796	5035382344	41·4004831	11·9675047	·0005834306
1715	2941225	5044200875	41·4125585	11·9698317	·0005830904
1716	2944656	5053029696	41·4246304	11·9721577	·0005827506
1717	2948089	5061868813	41·4366987	11·9744829	·0005824112
1718	2951524	5070718232	41·4487636	11·9768071	·0005820722
1719	2954961	5079577959	41·4608249	11·9791304	·0005817336
1720	2958400	5088448000	41·4728827	11·9814528	·0005813953
1721	2961841	5097328361	41·4849370	11·9837744	·0005810575
1722	2965284	5106219048	41·4969878	11·9860950	·0005807201
1723	2968729	5115120067	41·5090351	11·9884148	·0005803831
1724	2972176	5124031424	41·5210790	11·9907336	·0005800464
1725	2975625	5132953125	41·5331193	11·9930516	·0005797101
1726	2979076	5141885176	41·5451561	11·9953686	·0005793743
1727	2982529	5150827583	41·5571895	11·9976848	·0005790388
1728	2985984	5159780352	41·5692194	12·0000000	·0005787037
1729	2989441	5168743489	41·5812457	12·0023144	·0005783690
1730	2992900	5177717000	41·5932686	12·0046278	·0005780347
1731	2996361	5186700891	41·6052881	12·0069404	·0005777008
1732	2999824	5195695168	41·6173041	12·0092521	·0005773672
1733	3003289	5204699837	41·6293166	12·0115629	·0005770340
1734	3006756	5213714904	41·6413256	12·0138728	·0005767013
1735	3010225	5222740375	41·6533312	12·0161818	·0005763689
1736	3013696	5231776256	41·6653333	12·0184900	·0005760369
1737	3017169	5240822553	41·6773319	12·0207973	·0005757052
1738	3020644	5249879272	41·6893271	12·0231037	·0005753740
1739	3024121	5258946419	41·7013189	12·0254092	·0005750431
1740	3027600	5268024000	41·7133072	12·0277138	·0005747126
1741	3031081	5277112021	41·7252921	12·0300175	·0005743825
1742	3034564	5286210488	41·7372735	12·0323204	·0005740528
1743	3038049	5295319407	41·7492515	12·0346223	·0005737235
1744	3041536	5304438784	41·7612260	12·0369233	·0005733945
1745	3045025	5313568625	41·7731971	12·0392235	·0005730659
1746	3048516	5322708936	41·7851648	12·0415229	·0005727377
1747	3052009	5331859723	41·7971291	12·0438213	·0005724098
1748	3055504	5341020992	41·8090899	12·0461189	·0005720824
1749	3059001	5350192749	41·8210473	12·0484156	·0005717553
1750	3062500	5359375000	41·8330013	12·0507114	·0005714286
1751	3066001	5368567751	41·8449519	12·0530063	·0005711022
1752	3069504	5377771008	41·8568991	12·0553003	·0005707763
1753	3073009	5386984777	41·8688428	12·0575935	·0005704507
1754	3076516	5396209064	41·8807832	12·0598859	·0005701254
1755	3080025	5405443875	41·8927201	12·0621773	·0005698006
1756	3083536	5414689216	41·9046537	12·0644679	·0005694761
1757	3087049	5423945093	41·9165838	12·0667576	·0005691520
1758	3090564	5433211512	41·9285106	12·0690464	·0005688282
1759	3094081	5442488479	41·9404339	12·0713344	·0005685048
1760	3097600	5451776000	41·9523539	12·0736215	·0005681818

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1761	3101121	5461074081	41·9642705	12·0759077	·0005678592
1762	3104644	5470382728	41·9761837	12·0781930	·0005675369
1763	3108169	5479701947	41·9880935	12·0804775	·0005672150
1764	3111696	5489031744	42·0000000	12·0827612	·0005668934
1765	3115225	5498372125	42·0119031	12·0850439	·0005665722
1766	3118756	5507723096	42·0238028	12·0873258	·0005662514
1767	3122289	5517084663	42·0356991	12·0896069	·0005659310
1768	3125824	5526456832	42·0475921	12·0918870	·0005656109
1769	3129361	5535839609	42·0594817	12·0941664	·0005652911
1770	3132900	5545233000	42·0713679	12·0964449	·0005649718
1771	3136441	5554637011	42·0832508	12·0987226	·0005646527
1772	3139984	5564051648	42·0951304	12·1009993	·0005643341
1773	3143529	5573476917	42·1070065	12·1032753	·0005640158
1774	3147076	5582912824	42·1188794	12·1055503	·0005636979
1775	3150625	5592359375	42·1307488	12·1078245	·0005633803
1776	3154176	5601816576	42·1426150	12·1100979	·0005630631
1777	3157729	5611284433	42·1544778	12·1123704	·0005627462
1778	3161284	5620762952	42·1663373	12·1146420	·0005624297
1779	3164841	5630252139	42·1781934	12·1169128	·0005621135
1780	3168400	5639752000	42·1900462	12·1191827	·0005617978
1781	3171961	5649262541	42·2018957	12·1214518	·0005614823
1782	3175524	5658783768	42·2137418	12·1237200	·0005611672
1783	3179089	5668315687	42·2255846	12·1259874	·0005608525
1784	3182656	5677858304	42·2374242	12·1282539	·0005605381
1785	3186225	5687411625	42·2492603	12·1305197	·0005602241
1786	3189796	5696975656	42·2610932	12·1327845	·0005599104
1787	3193369	5706550403	42·2729227	12·1350485	·0005595971
1788	3196944	5716135872	42·2847490	12·1373117	·0005592841
1789	3200521	5725732069	42·2965719	12·1395740	·0005589715
1790	3204100	5735339000	42·3083916	12·1418355	·0005586592
1791	3207681	5744956671	42·3202079	12·1440961	·0005583473
1792	3211264	5754585088	42·3320210	12·1463559	·0005580357
1793	3214849	5764224257	42·3438307	12·1486148	·0005577245
1794	3218436	5773874184	42·3556371	12·1508729	·0005574136
1795	3222025	5783534875	42·3674403	12·1531302	·0005571031
1796	3225616	5793206336	42·3792402	12·1553866	·0005567929
1797	3229209	5802888573	42·3910368	12·1576422	·0005564830
1798	3232804	5812581592	42·4028301	12·1598970	·0005561735
1799	3236401	5822285399	42·4146201	12·1621509	·0005558644
1800	3240000	5832000000	42·4264069	12·1644040	·0005555556
1801	3243601	5841725401	42·4381903	12·1666562	·0005552471
1802	3247204	5851461608	42·4499705	12·1689076	·0005549390
1803	3250809	5861208627	42·4617475	12·1711582	·0005546312
1804	3254416	5870966464	42·4735212	12·1734079	·0005543237
1805	3258025	5880735125	42·4852916	12·1756569	·0005540166
1806	3261636	5890514616	42·4970587	12·1779050	·0005537099
1807	3265249	5900304943	42·5088226	12·1801522	·0005534034
1808	3268864	5910106112	42·5205833	12·1823987	·0005530973
1809	3272481	5919918129	42·5323406	12·1846443	·0005527916

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1810	3276100	5929741000	42·5440948	12·1868891	·0005524862
1811	3279721	5939574731	42·5558456	12·1891331	·0005521811
1812	3283344	5949419328	42·5675933	12·1913762	·0005518764
1813	3286969	5959274797	42·5793377	12·1936185	·0005515720
1814	3290596	5969141144	42·5910789	12·1958599	·0005512679
1815	3294225	5979018375	42·6028168	12·1981006	·0005509642
1816	3297856	5988906496	42·6145515	12·2003404	·0005506608
1817	3301489	5998805513	42·6262829	12·2025794	·0005503577
1818	3305124	6008715432	42·6380112	12·2048176	·0005500550
1819	3308761	6018636259	42·6497362	12·2070549	·0005497526
1820	3312400	6028568000	42·6614580	12·2092915	·0005494505
1821	3316041	6038510661	42·6731766	12·2115272	·0005491488
1822	3319684	6048464248	42·6848919	12·2137621	·0005488474
1823	3323329	6058428767	42·6966040	12·2159962	·0005485464
1824	3326976	6068404224	42·7083130	12·2182295	·0005482456
1825	3330625	6078390625	42·7200187	12·2204620	·0005479452
1826	3334276	6088387976	42·7317212	12·2226936	·0005476451
1827	3337929	6098396283	42·7434206	12·2249244	·0005473454
1828	3341584	6108415552	42·7551167	12·2271544	·0005470460
1829	3345241	6118445789	42·7668095	12·2293836	·0005467469
1830	3348900	6128487000	42·7784992	12·2316120	·0005464481
1831	3352561	6138539191	42·7901858	12·2338396	·0005461496
1832	3356224	6148602368	42·8018691	12·2360663	·0005458515
1833	3359889	6158676537	42·8135492	12·2382923	·0005455537
1834	3363556	6168761704	42·8252262	12·2405174	·0005452563
1835	3367225	6178857875	42·8368999	12·2427418	·0005449591
1836	3370896	6188965056	42·8485706	12·2449653	·0005446623
1837	3374569	6199083253	42·8602380	12·2471880	·0005443658
1838	3378244	6209212472	42·8719022	12·2494099	·0005440696
1839	3381921	6219352719	42·8835683	12·2516310	·0005437738
1840	3385600	6229504000	42·8952212	12·2538513	·0005434783
1841	3389281	6239666321	42·9068759	12·2560708	·0005431831
1842	3392964	6249839688	42·9185275	12·2582895	·0005428882
1843	3396649	6260024107	42·9301759	12·2605074	·0005425936
1844	3400336	6270219584	42·9418211	12·2627245	·0005422993
1845	3404025	6280426125	42·9534632	12·2649408	·0005420054
1846	3407716	6290643736	42·9651021	12·2671563	·0005417118
1847	3411409	6300872423	42·9767379	12·2693710	·0005414185
1848	3415104	6311112192	42·9883705	12·2715849	·0005411255
1849	3418801	6321363049	43·0000000	12·2737980	·0005408329
1850	3422500	6331625000	43·0116263	12·2760103	·0005405405
1851	3426201	6341898051	43·0232495	12·2782218	·0005402485
1852	3429904	6352182208	43·0348696	12·2804325	·0005399568
1853	3433609	6362477477	43·0464865	12·2826424	·0005396654
1854	3437316	6372783864	43·0581003	12·2848515	·0005393743
1855	3441025	6383101375	43·0697109	12·2870598	·0005390836
1856	3444736	6393430016	43·0813185	12·2892673	·0005387931
1857	3448449	6403769793	43·0929228	12·2914740	·0005385030
1858	3452164	6414120712	43·1045241	12·2936800	·0005382131

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1859	3455881	6424482779	43·1161223	12·2958851	·0005379236
1860	3459600	6434856000	43·1277173	12·2980895	·0005376344
1861	3463321	6445240381	43·1393092	12·3002930	·0005373455
1862	3467044	6455635928	43·1508980	12·3024958	·0005370569
1863	3470769	6466042647	43·1624837	12·3046978	·0005367687
1864	3474496	6476460544	43·1740663	12·3068990	·0005364807
1865	3478225	6486889625	43·1856458	12·3090994	·0005361930
1866	3481956	6497329896	43·1972221	12·3112991	·0005359057
1867	3485689	6507781363	43·2087954	12·3134979	·0005356186
1868	3489424	6518244032	43·2203656	12·3156959	·0005353319
1869	3493161	6528717909	43·2319326	12·3178932	·0005350455
1870	3496900	6539203000	43·2434966	12·3200897	·0005347594
1871	3500641	6549699311	43·2550575	12·3222854	·0005344735
1872	3504384	6560206848	43·2666153	12·3244803	·0005341880
1873	3508129	6570725617	43·2781700	12·3266744	·0005339028
1874	3511876	6581255624	43·2897216	12·3288678	·0005336179
1875	3515625	6591796875	43·3012702	12·3310604	·0005333333
1876	3519376	6602349376	43·3128157	12·3332522	·0005330490
1877	3523129	6612913133	43·3243580	12·3354432	·0005327651
1878	3526884	6623488152	43·3358973	12·3376334	·0005324814
1879	3530641	6634074439	43·3474336	12·3398229	·0005321980
1880	3534400	6644672000	43·3589668	12·3420116	·0005319149
1881	3538161	6655280841	43·3704969	12·3441995	·0005316321
1882	3541924	6665900968	43·3820239	12·3463866	·0005313496
1883	3545689	6676532387	43·3935479	12·3485730	·0005310674
1884	3549456	6687175104	43·4050688	12·3507586	·0005307856
1885	3553225	6697829125	43·4165867	12·3529434	·0005305040
1886	3556996	6708494456	43·4281015	12·3551274	·0005302227
1887	3560769	6719171103	43·4396132	12·3573107	·0005299417
1888	3564544	6729859072	43·4511220	12·3594932	·0005296610
1889	3568321	6740558369	43·4626276	12·3616749	·0005293806
1890	3572100	6751269000	43·4741302	12·3638559	·0005291005
1891	3575881	6761990971	43·4856298	12·3660361	·0005288207
1892	3579664	6772724288	43·4971263	12·3682155	·0005285412
1893	3583449	6783468957	43·5086198	12·3703941	·0005282620
1894	3587236	6794224984	43·5201103	12·3725721	·0005279831
1895	3591025	6804992375	43·5315977	12·3747492	·0005277045
1896	3594816	6815771136	43·5430821	12·3769255	·0005274262
1897	3598609	6826561273	43·5545635	12·3791011	·0005271481
1898	3602404	6837362792	43·5660418	12·3812759	·0005268704
1899	3606201	6848175699	43·5775171	12·3834500	·0005265929
1900	3610000	6859000000	43·5889894	12·3856233	·0005263158
1901	3613801	6869835701	43·6004587	12·3877959	·0005260389
1902	3617604	6880682808	43·6119249	12·3899676	·0005257624
1903	3621409	6891541327	43·6233882	12·3921386	·0005254861
1904	3625216	6902411264	43·6348485	12·3943089	·0005252101
1905	3629025	6913292625	43·6463057	12·3964784	·0005249344
1906	3632836	6924185416	43·6577599	12·3986471	·0005246590
1907	3636649	6935089643	43·6692111	12·4008151	·0005243838

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1908	3640464	6946005312	43·6806593	12·4029828	·0005241090
1909	3644281	6956932429	43·6921045	12·4051488	·0005238345
1910	3648100	6967871000	43·7035467	12·4073145	·0005235602
1911	3651921	6978821031	43·7149860	12·4094794	·0005232862
1912	3655744	6989782528	43·7264222	12·4116436	·0005230126
1913	3659569	7000755497	43·7378554	12·4138070	·0005227392
1914	3663396	7011739944	43·7492857	12·4159697	·0005224660
1915	3667225	7022735875	43·7607129	12·4181316	·0005221932
1916	3671056	7033743296	43·7721373	12·4202928	·0005219207
1917	3674889	7044762213	43·7835585	12·4224533	·0005216484
1918	3678724	7055792632	43·7949768	12·4246129	·0005213764
1919	3682561	7066834559	43·8063922	12·4267719	·0005211047
1920	3686400	7077888000	43·8178046	12·4289300	·0005208333
1921	3690241	7088952961	43·8292140	12·4310875	·0005205622
1922	3694084	7100029448	43·8406204	12·4332441	·0005202914
1923	3697929	7111117467	43·8520239	12·4354001	·0005200208
1924	3701776	7122217024	43·8634244	12·4375552	·0005197505
1925	3705625	7133328125	43·8748219	12·4397097	·0005194805
1926	3709476	7144450776	43·8862165	12·4418634	·0005192108
1927	3713329	7155584983	43·8976081	12·4440163	·0005189414
1928	3717184	7166730752	43·9089968	12·4461685	·0005186722
1929	3721041	7177888089	43·9203725	12·4483200	·0005184033
1930	3724900	7189057000	43·9317652	12·4504707	·0005181347
1931	3728761	7200237491	43·9431451	12·4526206	·0005178664
1932	3732624	7211429568	43·9545220	12·4547699	·0005175983
1933	3736489	7222633237	43·9658959	12·4569184	·0005173306
1934	3740356	7233848504	43·9772668	12·4590661	·0005170631
1935	3744225	7245075375	43·9886349	12·4612131	·0005167959
1936	3748096	7256313856	44·0000000	12·4633594	·0005165289
1937	3751969	7267563953	44·0113622	12·4655049	·0005162623
1938	3755844	7278825672	44·0227214	12·4676497	·0005159959
1939	3759721	7290099019	44·0340777	12·4697937	·0005157298
1940	3763600	7301384000	44·0454311	12·4719370	·0005154639
1941	3767481	7312680621	44·0567815	12·4740796	·0005151984
1942	3771364	7323988888	44·0681291	12·4762214	·0005149331
1943	3775249	7335308807	44·0794737	12·4783625	·0005146680
1944	3779136	7346640384	44·0908154	12·4805029	·0005144033
1945	3783025	7357983625	44·1021541	12·4826426	·0005141388
1946	3786916	7369338536	44·1134900	12·4847815	·0005138746
1947	3790809	7380705123	44·1248229	12·4869197	·0005136107
1948	3794704	7392083392	44·1361530	12·4890571	·0005133470
1949	3798601	7403473349	44·1474801	12·4911938	·0005130836
1950	3802500	7414875000	44·1588043	12·4933298	·0005128205
1951	3806401	7426288351	44·1701256	12·4954651	·0005125577
1952	3810304	7437713408	44·1814441	12·4975995	·0005122951
1953	3814209	7449150177	44·1027596	12·4997333	·0005120328
1954	3818116	7460598664	44·2040722	12·5018664	·0005117707
1955	3822025	7472058875	44·2153819	12·5039988	·0005115090
1956	3825936	7483530816	44·2266888	12·5061304	·0005112474

No.	Square	Cube	Square Root	Cube Root	Reciprocal
1957	3829849	7495014493	44·2379927	12·5082612	·0005109862
1958	3833764	7506509912	44·2492938	12·5103914	·0005107252
1959	3837681	7518017079	44·2605919	12·5125208	·0005104645
1960	3841600	7529536000	44·2718872	12·5146495	·0005102041
1961	3845521	7541066681	44·2831797	12·5167775	·0005099439
1962	3849444	7552609128	44·2944692	12·5189047	·0005096840
1963	3853369	7564163347	44·3057558	12·5210313	·0005094244
1964	3857296	7575729344	44·3170396	12·5231571	·0005091650
1965	3861225	7587307125	44·3283205	12·5252822	·0005089059
1966	3865156	7598896696	44·3395985	12·5274065	·0005086470
1967	3869089	7610498063	44·3508737	12·5295302	·0005083884
1968	3873024	7622111232	44·3621460	12·5316531	·0005081301
1969	3876961	7633736209	44·3734155	12·5337753	·0005078720
1970	3880900	7645373000	44·3846820	12·5358968	·0005076142
1971	3884841	7657021611	44·3959457	12·5380176	·0005073567
1972	3888784	7668682048	44·4072066	12·5401377	·0005070994
1973	3892729	7680354317	44·4184646	12·5422570	·0005068424
1974	3896676	7692038424	44·4297198	12·5443757	·0005065856
1975	3900625	7703734375	44·4409720	12·5464936	·0005063291
1976	3904576	7715442176	44·4522215	12·5486107	·0005060729
1977	3908529	7727161833	44·4634681	12·5507272	·0005058169
1978	3912484	7738893352	44·4747119	12·5528430	·0005055612
1979	3916441	7750636739	44·4859528	12·5549580	·0005053057
1980	3920400	7762392000	44·4971909	12·5570723	·0005050505
1981	3924361	7774159141	44·5084262	12·5591860	·0005047956
1982	3928324	7785938168	44·5196586	12·5612989	·0005045409
1983	3932289	7797729087	44·5308881	12·5634111	·0005042864
1984	3936256	7809531904	44·5421149	12·5655226	·0005040323
1985	3940225	7821346625	44·5533388	12·5676334	·0005037783
1986	3944196	7833173256	44·5645599	12·5697435	·0005035247
1987	3948169	7845011803	44·5757781	12·5718529	·0005032713
1988	3952144	7856862272	44·5869936	12·5739615	·0005030181
1989	3956121	7868724669	44·5982062	12·5760695	·0005027652
1990	3960100	7880599000	44·6094160	12·5781767	·0005025126
1991	3964081	7892485271	44·6206230	12·5802832	·0005022602
1992	3968064	7904383488	44·6318272	12·5823891	·0005020080
1993	3972049	7916293657	44·6430286	12·5844942	·0005017561
1994	3976036	7928215784	44·6542271	12·5865987	·0005015045
1995	3980025	7940149875	44·6654228	12·5887024	·0005012531
1996	3984016	7952095936	44·6766158	12·5908054	·0005010020
1997	3988009	7964053973	44·6878059	12·5929078	·0005007511
1998	3992004	7976023992	44·6989933	12·5950094	·0005005005
1999	3996001	7988005999	44·7101778	12·5971103	·0005002501
2000	4000000	8000000000	44·7213596	12·5992105	·0005000000
2001	4004001	8012006001	44·7325385	12·6013101	·0004997501
2002	4008004	8024024008	44·7437146	12·6034089	·0004995005
2003	4012009	8036054027	44·7548880	12·6055070	·0004992511
2004	4016016	8048096064	44·7660586	12·6076044	·0004990020
2005	4020025	8060150125	44·7772264	12·6097011	·0004987531

No.	Square	Cube	Square Root	Cube Root	Reciprocal
2006	4024036	8072216216	44·7883913	12·6117971	·0004985045
2007	4028049	8084294343	44·7995535	12·6138924	·0004982561
2008	4032064	8096384512	44·8107130	12·6159870	·0004980080
2009	4036081	8108486729	44·8218697	12·6180810	·0004977601
2010	4040100	8120601000	44·8330235	12·6201743	·0004975124
2011	4044121	8132727331	44·8441746	12·6222669	·0004972650
2012	4048144	8144865728	44·8553230	12·6243587	·0004970179
2013	4052169	8157016197	44·8664685	12·6264499	·0004967710
2014	4056196	8169178744	44·8776113	12·6285404	·0004965243
2015	4060225	8181353375	44·8887514	12·6306301	·0004962779
2016	4064256	8193540096	44·8998886	12·6327192	·0004960317
2017	4068289	8205738913	44·9110231	12·6348076	·0004957858
2018	4072324	8217949832	44·9221549	12·6368953	·0004955401
2019	4076361	8230172859	44·9332839	12·6389823	·0004952947
2020	4080400	8242408000	44·9444101	12·6410687	·0004950495
2021	4084441	8254655261	44·9555336	12·6431543	·0004948046
2022	4088484	8266914648	44·9666543	12·6452393	·0004945598
2023	4092529	8279186167	44·9777723	12·6473235	·0004943154
2024	4096576	8291469824	44·9888875	12·6494071	·0004940711
2025	4100625	8303765625	45·0000000	12·6514900	·0004938272
2026	4104676	8316073576	45·0111097	12·6535722	·0004935834
2027	4108729	8328393683	45·0222167	12·6556538	·0004933399
2028	4112784	8340725952	45·0333210	12·6577346	·0004930966
2029	4116841	8353070389	45·0444225	12·6598148	·0004928536
2030	4120900	8365427000	45·0555213	12·6618943	·0004926108
2031	4124961	8377795791	45·0666173	12·6639731	·0004923683
2032	4129024	8390176768	45·0777107	12·6660512	·0004921260
2033	4133089	8402569937	45·0888013	12·6681286	·0004918839
2034	4137156	8414975304	45·0998891	12·6702053	·0004916421
2035	4141225	8427392875	45·1109743	12·6722814	·0004914005
2036	4145296	8439822656	45·1220567	12·6743567	·0004911591
2037	4149369	8452264653	45·1331364	12·6764314	·0004909180
2038	4153444	8464718872	45·1442134	12·6785054	·0004906771
2039	4157521	8477185319	45·1552876	12·6805788	·0004904365
2040	4161600	8489664000	45·1663592	12·6826514	·0004901961
2041	4165681	8502154921	45·1774280	12·6847234	·0004899559
2042	4169764	8514658088	45·1884941	12·6867947	·0004897160
2043	4173849	8527173507	45·1995575	12·6888654	·0004894762
2044	4177936	8539701184	45·2106182	12·6909354	·0004892368
2045	4182025	8552241125	45·2216762	12·6930047	·0004889976
2046	4186116	8564793336	45·2327315	12·6950733	·0004887586
2047	4190209	8577357823	45·2437841	12·6971412	·0004885198
2048	4194304	8589934592	45·2548340	12·6992084	·0004882813
2049	4198401	8602523649	45·2658812	12·7012750	·0004880429
2050	4202500	8615125000	45·2769257	12·7033409	·0004878049
2051	4206601	8627738651	45·2879675	12·7054061	·0004875670
2052	4210704	8640364608	45·2990066	12·7074707	·0004873294
2053	4214809	8653002877	45·3100430	12·7095346	·0004870921
2054	4218916	8665653464	45·3210768	12·7115978	·0004868549

No.	Square	Cube	Square Root	Cube Root	Reciprocal
2055	4223025	8678316375	45·3321078	12·7136603	·0004866180
2056	4227136	8690991616	45·3431362	12·7157222	·0004863813
2057	4231249	8703679193	45·3541619	12·7177835	·0004861449
2058	4235364	8716379112	45·3651849	12·7198441	·0004859086
2059	4239481	8729091379	45·3762052	12·7219040	·0004856727
2060	4243600	8741816000	45·3872229	12·7239632	·0004854369
2061	4247721	8754552981	45·3982378	12·7260218	·0004852014
2062	4251844	8767302328	45·4092501	12·7280797	·0004849661
2063	4255969	8780064047	45·4202598	12·7301370	·0004847310
2064	4260096	8792838144	45·4312668	12·7321935	·0004844961
2065	4264225	8805624625	45·4422711	12·7342494	·0004842615
2066	4268356	8818423496	45·4532727	12·7363046	·0004840271
2067	4272489	8831234763	45·4642717	12·7383592	·0004837929
2068	4276624	8844058432	45·4752680	12·7404131	·0004835590
2069	4280761	8856894509	45·4862616	12·7424664	·0004833253
2070	4284900	8869743000	45·4972526	12·7445189	·0004830918
2071	4289041	8882603911	45·5082410	12·7465709	·0004828585
2072	4293184	8895477248	45·5192267	12·7486222	·0004826255
2073	4297329	8908363017	45·5302097	12·7506728	·0004823927
2074	4301476	8921261224	45·5411901	12·7527227	·0004821601
2075	4305625	8934171875	45·5521679	12·7547721	·0004819277
2076	4309776	8947094976	45·5631430	12·7568207	·0004816956
2077	4313929	8960030533	45·5741155	12·7588687	·0004814636
2078	4318084	8972978552	45·5850853	12·7609160	·0004812320
2079	4322241	8985939039	45·5960525	12·7629627	·0004810005
2080	4326400	8998912000	45·6070170	12·7650087	·0004807692
2081	4330561	9011897441	45·6179789	12·7670540	·0004805382
2082	4334724	9024895368	45·6289382	12·7690987	·0004803074
2083	4338889	9037905787	45·6398948	12·7711427	·0004800768
2084	4343056	9050928704	45·6508488	12·7731861	·0004798464
2085	4347225	9063964125	45·6618002	12·7752288	·0004796163
2086	4351396	9077012056	45·6727490	12·7772709	·0004793864
2087	4355569	9090072503	45·6836951	12·7793123	·0004791567
2088	4359744	9103145472	45·6946386	12·7813531	·0004789272
2089	4363921	9116230969	45·7055795	12·7833932	·0004786979
2090	4368100	9129329000	45·7165178	12·7854326	·0004784689
2091	4372281	9142439571	45·7274534	12·7874714	·0004782401
2092	4376464	9155562688	45·7383865	12·7895096	·0004780115
2093	4380649	9168698357	45·7493169	12·7915471	·0004777831
2094	4384836	9181846584	45·7602447	12·7935840	·0004775549
2095	4389025	9195007375	45·7711699	12·7956202	·0004773270
2096	4393216	9208180736	45·7820926	12·7976558	·0004770992
2097	4397409	9221366673	45·7930126	12·7996907	·0004768717
2098	4401604	9234565192	45·8039299	12·8017250	·0004766444
2099	4405801	9247776299	45·8148447	12·8037586	·0004764173
2100	4410000	9261000000	45·8257569	12·8057916	·0004761905
2101	4414201	9274236301	45·8366665	12·8078239	·0004759638
2102	4418404	9287485208	45·8475735	12·8098556	·0004757374
2103	4422609	9300746727	45·8584779	12·8118866	·0004755112

No.	Square	Cube	Square Root	Cube Root	Reciprocal
2104	4426816	9314020864	45·8693798	12·8139170	·0004752852
2105	4431025	9327307625	45·8802790	12·8159468	·0004750594
2106	4435236	9340607016	45·8911756	12·8179759	·0004748338
2107	4439449	9353919043	45·9020696	12·8200044	·0004746084
2108	4443664	9367243712	45·9129611	12·8220323	·0004743833
2109	4447881	9380581029	45·9238500	12·8240595	·0004741584
2110	4452100	9393931000	45·9347363	12·8260861	·0004739336
2111	4456321	9407293631	45·9456200	12·8281120	·0004737091
2112	4460544	9420668928	45·9565012	12·8301373	·0004734848
2113	4464769	9434056897	45·9673798	12·8321620	·0004732608
2114	4468996	9447457544	45·9782557	12·8341860	·0004730369
2115	4473225	9460870875	45·9891291	12·8362094	·0004728132
2116	4477456	9474296896	46·0000000	12·8382321	·0004725898
2117	4481689	9487735613	46·0108683	12·8402542	·0004723666
2118	4485924	9501187032	46·0217340	12·8422756	·0004721435
2119	4490161	9514651159	46·0325971	12·8442964	·0004719207
2120	4494400	9528128000	46·0434577	12·8463166	·0004716981
2121	4498641	9541617561	46·0543158	12·8483361	·0004714757
2122	4502884	9555119848	46·0651712	12·8503551	·0004712535
2123	4507129	9568634867	46·0760241	12·8523733	·0004710316
2124	4511376	9582162624	46·0868745	12·8543910	·0004708098
2125	4515625	9595703125	46·0977223	12·8564080	·0004705882
2126	4519876	9609256376	46·1085675	12·8584243	·0004703669
2127	4524129	9622822383	46·1194102	12·8604401	·0004701457
2128	4528384	9636401152	46·1302504	12·8624552	·0004699248
2129	4532641	9649992689	46·1410880	12·8644697	·0004697041
2130	4536900	9663597000	46·1519230	12·8664835	·0004694836
2131	4541161	9677214091	46·1627555	12·8684967	·0004692633
2132	4545424	9690843968	46·1735855	12·8705093	·0004690432
2133	4549689	9704486637	46·1844130	12·8725213	·0004688233
2134	4553956	9718142104	46·1952378	12·8745326	·0004686036
2135	4558225	9731810375	46·2060602	12·8765433	·0004683841
2136	4562496	9745491456	46·2168800	12·8785534	·0004681648
2137	4566769	9759185353	46·2276973	12·8805628	·0004679457
2138	4571044	9772892072	46·2385121	12·8825717	·0004677268
2139	4575321	9786611619	46·2493243	12·8845199	·0004675082
2140	4579600	9800344000	46·2601340	12·8865874	·0004672897
2141	4583881	9814089221	46·2709412	12·8885944	·0004670715
2142	4588164	9827847288	46·2817459	12·8906007	·0004668534
2143	4592449	9841618207	46·2925480	12·8926064	·0004666356
2144	4596736	9855401984	46·3033476	12·8946115	·0004664179
2145	4601025	9869198625	46·3141447	12·8966159	·0004662005
2146	4605316	9883008136	46·3249393	12·8986197	·0004659832
2147	4609609	9896830523	46·3357314	12·9006229	·0004657662
2148	4613904	9910665792	46·3465209	12·9026255	·0004655493
2149	4618201	9924513949	46·3573079	12·9046275	·0004653327
2150	4622500	9938375000	46·3680924	12·9066288	·0004651163
2151	4626801	9952248951	46·3788745	12·9086295	·0004649000
2152	4631104	9966135808	46·3896540	12·9106296	·0004646840

No.	Square	Cube	Square Root	Cube Root	Reciprocal
2153	4635409	9980035577	46·4004310	12·9126291	·0004644682
2154	4639716	9993948264	46·4112055	12·9146279	·0004642526
2155	4644025	10007873875	46·4219775	12·9166262	·0004640371
2156	4648336	10021812416	46·4327471	12·9186238	·0004638219
2157	4652649	10035763893	46·4435141	12·9206208	·0004636069
2158	4656964	10049728312	46·4542786	12·9226172	·0004633920
2159	4661281	10063705679	46·4650406	12·9246129	·0004631774
2160	4665600	10077696000	46·4758002	12·9266081	·0004629630
2161	4669921	10091699281	46·4865572	12·9286027	·0004627487
2162	4674244	10105715528	46·4973118	12·9305966	·0004625347
2163	4678569	10119744747	46·5080638	12·9325899	·0004623209
2164	4682896	10133786944	46·5188134	12·9345827	·0004621072
2165	4687225	10147842125	46·5295605	12·9365747	·0004618938
2166	4691556	10161910296	46·5403051	12·9385662	·0004616805
2167	4695889	10175991463	46·5510472	12·9405570	·0004614675
2168	4700224	10190085632	46·5617869	12·9425472	·0004612546
2169	4704561	10204192809	46·5725241	12·9445369	·0004610420
2170	4708900	10218313000	46·5832588	12·9465259	·0004608295
2171	4713241	10232446211	46·5939910	12·9485143	·0004606172
2172	4717584	10246592448	46·6047208	12·9505021	·0004604052
2173	4721929	10260751717	46·6154481	12·9524893	·0004601933
2174	4726276	10274924024	46·6261729	12·9544759	·0004599816
2175	4730625	10289109375	46·6368953	12·9564618	·0004597701
2176	4734976	10303307776	46·6476152	12·9584472	·0004595588
2177	4739329	10317519233	46·6583326	12·9604319	·0004593477
2178	4743684	10331743752	46·6690476	12·9624161	·0004591368
2179	4748041	10345981339	46·6797601	12·9643996	·0004589261
2180	4752400	10360232000	46·6904701	12·9663826	·0004587156
2181	4756761	10374495741	46·7011777	12·9683649	·0004585053
2182	4761124	10388772568	46·7118829	12·9703466	·0004582951
2183	4765489	10403062487	46·7225855	12·9723277	·0004580852
2184	4769856	10417365504	46·7332858	12·9743082	·0004578755
2185	4774225	10431681625	46·7439836	12·9762881	·0004576659
2186	4778596	10446010856	46·7546789	12·9782674	·0004574565
2187	4782969	10460353203	46·7653718	12·9802461	·0004572474
2188	4787344	10474708672	46·7760623	12·9822242	·0004570384
2189	4791721	10489077269	46·7867503	12·9842017	·0004568296
2190	4796100	10503459000	46·7974358	12·9861786	·0004566210
2191	4800481	10517853871	46·8081189	12·9881549	·0004564126
2192	4804864	10532261888	46·8187996	12·9901306	·0004562044
2193	4809249	10546683057	46·8294779	12·9921057	·0004559964
2194	4813636	10561117384	46·8401537	12·9940802	·0004557885
2195	4818025	10575564875	46·8508271	12·9960540	·0004555809
2196	4822416	10590025536	46·8614981	12·9980273	·0004553734
2197	4826809	10604499373	46·8721666	13·0000000	·0004551661
2198	4831204	10618986392	46·8828327	13·0019721	·0004549591
2199	4835601	10633486599	46·8934963	13·0039436	·0004547522
2200	4840000	10648000000	46·9041576	13·0059145	·0004545455
2201	4844401	10662526601	46·9148164	13·0078848	·0004543389

TABLE OF LOGARITHMS OF NUMBERS FROM 1 TO 10000.

Indices of Logarithms.

The index of the logarithm of a number is one less than the number of integral figures used in expressing that number.

Number	Logarithm	Number	Logarithm	Number	Logarithm
4134	3·6163705	41·34	1·6163705	·4134	−1·6163705
413·4	2·6163705	4·134	0·6163705	·04134	−2·6163705

Note.—The decimal part of the logarithm is always positive.

To Find the Logarithm of a Number.

Find log. of 837·2468

Log. of 837·2000 = 2·9228292

Tab. diff. 519 × 468 = 243

Log. required. 2·9228535

Find log. of 830465

Log. of 830400 = 5·9192873

Tab. diff. 525 × 65 = 339

Log. required 5·9193212

To Find the Number corresponding to a given Logarithm.

Find number of logarithm 2·9228535

Logarithm of 837·2000 = 2·9228292

243000 ÷ diff. 519 = 468   243

837·2468

Find number of logarithm 5·9193212

Logarithm of 830400 = 5·9192873

33900 ÷ diff. 521 = 65   339

830465

To Multiply by Logarithms.

Find the product of 84 × 56 × 37 × 8

Log. of 84 = 1·9242793

„ 56 = 1·7481880

„ 37 = 1·5682017

„ 8 = 0·9030900

Product 1392384 log. = 6·1437590

To find the product of ·37 × 426 × ·5 × ·004

Log. of ·37 = −1·5682017

„ 426 = +2·6294096

„ ·5 = −1·6989700

„ ·004 = −3·6020600

Sum of decimals and positive indices + 4·4986413

Sum of negative indices − 5

Prod. ·31524 log. = −1·4986413

TABLE OF LOGARITHMS—*continued.*

To Divide by Logarithms.

Divide 785·925 by 25

Log. of 785·925 = 2·8953811
„ 25 = 1·3979400
Quotient 31·437 log. = 1·4974411

Divide 31·25 by 125

Log. 31·25 = 1·4948500
„ ·125 = $\bar{2}$·0969100
Quot. ·25 log. = −1·3979400

Divide ·07438 by 129·476

Log. ·07438 = −2·8714562
„ 129·476 = 2·1121893
Quotient ·0005744 log. = −4·7592669

Divide ·0565 by ·25

Log. ·0565 = −2·7520484
„ ·25 = −1·3979400
Quotient ·226 log. = −1·3541084

To Raise a Number to any Power.

$14·72^3$

Log. 14·72 = 1·1679078
Index of power 3
Product of the decimal 0·5037234
Prod. of ind. + 1 × 3 = 3
3189·506 log. = +3·5037234
$14·72^3$ = 3189·506

$·0032^{·625}$

Log. ·0032 = −3·5051500
·625
+0·31571875
−3 × ·625 = −1·875
·0275879 log. = −2·44071875
∴ $·0032^{·625}$ = ·0275879

To Extract the Root of any Number.

$\sqrt[3]{3189·506}$

Log. 3189·506 = 3·5037234
Its quotient by 3 = 1·1679078
Log. 14·72 = 1·1679078
∴ $\sqrt[3]{3189·506}$ = 14·72

$\sqrt[4]{·0076542}$

Log. ·0076542 = −3·8838998
= −4 + 1·8838998 ÷ 4 = −1·4709749
Log. ·295784 = −1·4709749
∴ $\sqrt[4]{·0076542}$ = ·295784

No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
1	·0000000	21	1·3222193	41	1·6127839	61	1·7853298	81	1·9084850
2	·3010300	22	1·3424227	42	1·6232493	62	1·7923917	82	1·9138139
3	·4771213	23	1·3617278	43	1·6334685	63	1·7993405	83	1·9190781
4	·6020600	24	1·3802112	44	1·6434527	64	1·8061800	84	1·9242793
5	·6989700	25	1·3979400	45	1·6532125	65	1·8129134	85	1·9294189
6	·7781513	26	1·4149733	46	1·6627578	66	1·8195439	86	1·9344985
7	·8450980	27	1·4313638	47	1·6720979	67	1·8260748	87	1·9395193
8	·9030900	28	1·4471580	48	1·6812412	68	1·8825089	88	1·9444827
9	·9542425	29	1·4623980	49	1·6901961	69	1·8388491	89	1·9493900
10	1·0000000	30	1·4771213	50	1·6989700	70	1·8450980	90	1·9542425
11	1·0413927	31	1·4913617	51	1·7075702	71	1·8512583	91	1·9590414
12	1·0791812	32	1·5051500	52	1·7160033	72	1·8573325	92	1·9637878
13	1·1139434	33	1·5185139	53	1·7242759	73	1·8633229	93	1·9684829
14	1·1461280	34	1·5314789	54	1·7323938	74	1·8692317	94	1·9731279
15	1·1760913	35	1·5440680	55	1·7403627	75	1·8750613	95	1·9777236
16	1·2041200	36	1·5563025	56	1·7481880	76	1·8808136	96	1·9822712
17	1·2304489	37	1·5682017	57	1·7558749	77	1·8864907	97	1·9867717
18	1·2552725	38	1·5797836	58	1·7634280	78	1·8920946	98	1·9912261
19	1·2787536	39	1·5910646	59	1·7708520	79	1·8976271	99	1·9956352
20	1·3010300	40	1·6020600	60	1·7781513	80	1·9030900	100	2·0000000

No.	0	1	2	3	4	5	6	7	8	9	Diff.
100	·0000000	·0004341	·0008677	·0013009	·0017337	·0021661	·0025980	·0030295	·0034605	·0038912	4322
101	·0043214	·0047512	·0051805	·0056094	·0060380	·0064660	·0068937	·0073210	·0077478	·0081742	4280
102	·0086002	·0090257	·0094509	·0098756	·0103000	·0107239	·0111474	·0115704	·0119931	·0124154	4237
103	·0128372	·0132587	·0136797	·0141003	·0145205	·0149403	·0153598	·0157788	·0161974	·0166155	4197
104	·0170333	·0174507	·0178677	·0182843	·0187005	·0191163	·0195317	·0199467	·0203613	·0207755	4152
105	·0211893	·0216027	·0220157	·0224284	·0228406	·0232525	·0236639	·0240750	·0244857	·0248960	4117
106	·0253059	·0257154	·0261245	·0265333	·0269416	·0273496	·0277572	·0281644	·0285713	·0289777	4078
107	·0293838	·0297895	·0301948	·0305997	·0310043	·0314085	·0318123	·0322157	·0326188	·0330214	4040
108	·0334238	·0338257	·0342273	·0346285	·0350293	·0354297	·0358298	·0362295	·0366289	·0370279	4003
109	·0374265	·0378248	·0382226	·0386202	·0390173	·0394141	·0398106	·0402066	·0406023	·0409977	3966
110	·0413927	·0417873	·0421816	·0425755	·0429691	·0433623	·0437551	·0441476	·0445398	·0449315	3931
111	·0453230	·0457141	·0461048	·0464952	·0468852	·0472749	·0476642	·0480532	·0484418	·0488301	3895
112	·0492180	·0496056	·0499929	·0503798	·0507663	·0511525	·0515384	·0519239	·0523091	·0526939	3861
113	·0530784	·0534626	·0538464	·0542299	·0546131	·0549959	·0553783	·0557605	·0561423	·0565237	3827
114	·0569049	·0572856	·0576661	·0580462	·0584260	·0588055	·0591846	·0595634	·0599419	·0603200	3796
115	·0606978	·0610753	·0614525	·0618293	·0622058	·0625820	·0629578	·0633334	·0637086	·0640834	3761
116	·0644580	·0648322	·0652061	·0655797	·0659530	·0663259	·0666986	·0670709	·0674428	·0678145	3728
117	·0681859	·0685569	·0689276	·0692980	·0696681	·0700379	·0704073	·0707765	·0711453	·0715138	3697
118	·0718820	·0722499	·0726175	·0729847	·0733517	·0737184	·0740847	·0744507	·0748164	·0751819	3665
119	·0755470	·0759118	·0762763	·0766404	·0770043	·0773679	·0777312	·0780942	·0784568	·0788192	3635
120	·0791812	·0795430	·0799045	·0802656	·0806265	·0809870	·0813473	·0817073	·0820669	·0824263	3605
121	·0827854	·0831441	·0835026	·0838608	·0842187	·0845763	·0849336	·0852906	·0856473	·0860037	3575
122	·0863598	·0867157	·0870712	·0874265	·0877814	·0881361	·0884905	·0888446	·0891984	·0895519	3546
123	·0899051	·0902581	·0906107	·0909631	·0913152	·0916670	·0920185	·0923697	·0927206	·0930713	3517
124	·0934217	·0937718	·0941216	·0944711	·0948204	·0951694	·0955180	·0958665	·0962146	·0965624	3489
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
125	·0969100	·0972573	·0976043	·0979511	·0982975	·0986437	·0989896	·0993353	·0996806	·1000257	3461
126	·1003705	·1007151	·1010594	·1014034	·1017471	·1020905	·1024337	·1027766	·1031193	·1034616	3433
127	·1038037	·1041456	·1044871	·1048284	·1051694	·1055102	·1058507	·1061909	·1065309	·1068705	3406
128	·1072100	·1075491	·1078880	·1082267	·1085650	·1089031	·1092410	·1095785	·1099159	·1102529	3380
129	·1105897	·1109262	·1112625	·1115985	·1119343	·1122698	·1126050	·1129400	·1132747	·1136092	3354
130	·1139434	·1142773	·1146110	·1149444	·1152776	·1156105	·1159432	·1162756	·1166077	·1169396	3328
131	·1172713	·1176027	·1179338	·1182647	·1185954	·1189258	·1192559	·1195858	·1199154	·1202448	3302
132	·1205739	·1209028	·1212315	·1215598	·1218880	·1222159	·1225435	·1228709	·1231981	·1235250	3278
133	·1238516	·1241781	·1245042	·1248301	·1251558	·1254813	·1258065	·1261314	·1264561	·1267806	3254
134	·1271048	·1274288	·1277525	·1280760	·1283993	·1287223	·1290451	·1293676	·1296899	·1300119	3229
135	·1303338	·1306553	·1309767	·1312978	·1316187	·1319393	·1322597	·1325798	·1328998	·1332195	3206
136	·1335389	·1338581	·1341771	·1344959	·1348144	·1351327	·1354507	·1357685	·1360861	·1364034	3182
137	·1367206	·1370375	·1373541	·1376705	·1379867	·1383027	·1386184	·1389339	·1392492	·1395643	3159
138	·1398791	·1401937	·1405080	·1408222	·1411361	·1414498	·1417632	·1420765	·1423895	·1427022	3136
139	·1430148	·1433271	·1436392	·1439511	·1442628	·1445742	·1448854	·1451964	·1455072	·1458177	3113
140	·1461280	·1464381	·1467480	·1470577	·1473671	·1476763	·1479853	·1482941	·1486027	·1489110	3091
141	·1492191	·1495270	·1498347	·1501422	·1504494	·1507564	·1510633	·1513699	·1516762	·1519824	3070
142	·1522883	·1525941	·1528996	·1532049	·1535100	·1538149	·1541195	·1544240	·1547282	·1550322	3048
143	·1553360	·1556396	·1559430	·1562462	·1565492	·1568519	·1571544	·1574568	·1577589	·1580608	3026
144	·1583625	·1586640	·1589653	·1592663	·1595672	·1598678	·1601683	·1604685	·1607686	·1610684	3006
145	·1613680	·1616674	·1619666	·1622656	·1625644	·1628630	·1631614	·1634596	·1637575	·1640553	2985
146	·1643529	·1646502	·1649474	·1652443	·1655411	·1658376	·1661340	·1664301	·1667261	·1670218	2965
147	·1673173	·1676127	·1679078	·1682027	·1684975	·1687920	·1690864	·1693805	·1696744	·1699682	2945
148	·1702617	·1705551	·1708482	·1711412	·1714339	·1717265	·1720188	·1723110	·1726029	·1728947	2925
149	·1731863	·1734776	·1737688	·1740598	·1743506	·1746412	·1749316	·1752218	·1755118	·1758016	2905
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·0000000	·0004341	·0008677	·0013009	·0017337	·0021661	·0025980	·0030295	·0034605	·0038912	4322
01	·0043214	·0047512	·0051805	·0056094	·0060380	·0064660	·0068937	·0073210	·0077478	·0081742	4280
02	·0086002	·0090257	·0094509	·0098756	·0103000	·0107239	·0111474	·0115704	·0119931	·0124154	4237
03	·0128372	·0132587	·0136797	·0141003	·0145205	·0149403	·0153598	·0157788	·0161974	·0166155	4197
04	·0170333	·0174507	·0178677	·0182843	·0187005	·0191163	·0195317	·0199467	·0203613	·0207755	4152
05	·0211893	·0216027	·0220157	·0224284	·0228406	·0232525	·0236639	·0240750	·0244857	·0248960	4117
06	·0253059	·0257154	·0261245	·0265333	·0269416	·0273496	·0277572	·0281644	·0285713	·0289777	4078
07	·0293838	·0297895	·0301948	·0305997	·0310043	·0314085	·0318123	·0322157	·0326188	·0330214	4040
08	·0334238	·0338257	·0342273	·0346285	·0350293	·0354297	·0358298	·0362295	·0366289	·0370279	4003
09	·0374265	·0378248	·0382226	·0386202	·0390173	·0394141	·0398106	·0402066	·0406023	·0409977	3966
10	·0413927	·0417873	·0421816	·0425755	·0429691	·0433623	·0437551	·0441476	·0445398	·0449315	3931
11	·0453230	·0457141	·0461048	·0464952	·0468852	·0472749	·0476642	·0480532	·0484418	·0488301	3895
12	·0492180	·0496056	·0499929	·0503798	·0507663	·0511525	·0515384	·0519239	·0523091	·0526939	3861
13	·0530784	·0534626	·0538464	·0542299	·0546131	·0549959	·0553783	·0557605	·0561423	·0565237	3827
14	·0569049	·0572856	·0576661	·0580462	·0584260	·0588055	·0591846	·0595634	·0599419	·0603200	3796
15	·0606978	·0610753	·0614525	·0618293	·0622058	·0625820	·0629578	·0633334	·0637086	·0640834	3761
16	·0644580	·0648322	·0652061	·0655797	·0659530	·0663259	·0666986	·0670709	·0674428	·0678145	3728
17	·0681859	·0685569	·0689276	·0692980	·0696681	·0700379	·0704073	·0707765	·0711453	·0715138	3697
18	·0718820	·0722499	·0726175	·0729847	·0733517	·0737184	·0740847	·0744507	·0748164	·0751819	3665
19	·0755470	·0759118	·0762763	·0766404	·0770043	·0773679	·0777312	·0780942	·0784568	·0788192	3635
20	·0791812	·0795430	·0799045	·0802656	·0806265	·0809870	·0813473	·0817078	·0820669	·0824263	3605
21	·0827854	·0831441	·0835026	·0838608	·0842187	·0845763	·0849336	·0852906	·0856473	·0860037	3575
22	·0863598	·0867157	·0870712	·0874265	·0877814	·0881361	·0884905	·0888446	·0891984	·0895519	3546
23	·0899051	·0902581	·0906107	·0909631	·0913152	·0916670	·0920185	·0923697	·0927206	·0930713	3517
24	·0934217	·0937718	·0941216	·0944711	·0948204	·0951694	·0955180	·0958665	·0962146	·0965624	3489
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
125	·0969100	·0972573	·0976043	·0979511	·0982975	·0986437	·0989896	·0993353	·0996806	·1000257	3461
126	·1003705	·1007151	·1010594	·1014034	·1017471	·1020905	·1024337	·1027766	·1031193	·1034616	3433
127	·1038037	·1041456	·1044871	·1048284	·1051694	·1055102	·1058507	·1061909	·1065309	·1068705	3406
128	·1072100	·1075491	·1078880	·1082267	·1085650	·1089031	·1092410	·1095785	·1099159	·1102529	3380
129	·1105897	·1109262	·1112625	·1115985	·1119343	·1122698	·1126050	·1129400	·1132747	·1136092	3354
130	·1139434	·1142773	·1146110	·1149444	·1152776	·1156105	·1159432	·1162756	·1166077	·1169396	3328
131	·1172713	·1176027	·1179338	·1182647	·1185954	·1189258	·1192559	·1195858	·1199154	·1202448	3302
132	·1205739	·1209028	·1212315	·1215598	·1218880	·1222159	·1225435	·1228709	·1231981	·1235250	3278
133	·1238516	·1241781	·1245042	·1248301	·1251558	·1254813	·1258065	·1261314	·1264561	·1267806	3254
134	·1271048	·1274288	·1277525	·1280760	·1283993	·1287223	·1290451	·1293676	·1296899	·1300119	3229
135	·1303338	·1306553	·1309767	·1312978	·1316187	·1319393	·1322597	·1325798	·1328998	·1332195	3206
136	·1335389	·1338581	·1341771	·1344959	·1348144	·1351327	·1354507	·1357685	·1360861	·1364034	3182
137	·1367206	·1370375	·1373541	·1376705	·1379867	·1383027	·1386184	·1389339	·1392492	·1395643	3159
138	·1398791	·1401937	·1405080	·1408222	·1411361	·1414498	·1417632	·1420765	·1423895	·1427022	3136
139	·1430148	·1433271	·1436392	·1439511	·1442628	·1445742	·1448854	·1451964	·1455072	·1458177	3113
140	·1461280	·1464381	·1467480	·1470577	·1473671	·1476763	·1479853	·1482941	·1486027	·1489110	3091
141	·1492191	·1495270	·1498347	·1501422	·1504494	·1507564	·1510633	·1513699	·1516762	·1519824	3070
142	·1522883	·1525941	·1528996	·1532049	·1535100	·1538149	·1541195	·1544240	·1547282	·1550322	3048
143	·1553360	·1556396	·1559430	·1562462	·1565492	·1568519	·1571544	·1574568	·1577589	·1580608	3026
144	·1583625	·1586640	·1589653	·1592663	·1595672	·1598678	·1601683	·1604685	·1607686	·1610684	3006
145	·1613680	·1616674	·1619666	·1622656	·1625644	·1628630	·1631614	·1634596	·1637575	·1640553	2985
146	·1643529	·1646502	·1649474	·1652443	·1655411	·1658376	·1661340	·1664301	·1667261	·1670218	2965
147	·1673173	·1676127	·1679078	·1682027	·1684975	·1687920	·1690864	·1693805	·1696744	·1699682	2945
148	·1702617	·1705551	·1708482	·1711412	·1714339	·1717265	·1720188	·1723110	·1726029	·1728947	2925
149	·1731863	·1734776	·1737688	·1740598	·1743506	·1746412	·1749316	·1752218	·1755118	·1758016	2905
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
150	·1760913	·1763807	·1766699	·1769590	·1772478	·1775365	·1778250	·1781133	·1784013	·1786892	2886
151	·1789769	·1792645	·1795518	·1798389	·1801259	·1804126	·1806992	·1809856	·1812718	·1815578	2867
152	·1818436	·1821292	·1824147	·1826999	·1829850	·1832698	·1835545	·1838390	·1841234	·1844075	2848
153	·1846914	·1849752	·1852588	·1855422	·1858254	·1861084	·1863912	·1866739	·1869563	·1872386	2829
154	·1875207	·1878026	·1880844	·1883659	·1886473	·1889285	·1892095	·1894903	·1897710	·1900514	2811
155	·1903317	·1906118	·1908917	·1911715	·1914510	·1917304	·1920096	·1922886	·1925675	·1928461	2793
156	·1931246	·1934029	·1936810	·1939590	·1942367	·1945143	·1947918	·1950690	·1953461	·1956229	2775
157	·1958997	·1961762	·1964525	·1967287	·1970047	·1972806	·1975562	·1978317	·1981070	·1983821	2757
158	·1986571	·1989319	·1992065	·1994809	·1997552	·2000293	·2003032	·2005769	·2008505	·2011239	2741
159	·2013971	·2016702	·2019431	·2022158	·2024883	·2027607	·2030329	·2033049	·2035768	·2038485	2723
160	·2041200	·2043913	·2046625	·2049335	·2052044	·2054750	·2057455	·2060159	·2062860	·2065560	2706
161	·2068259	·2070955	·2073650	·2076344	·2079035	·2081725	·2084414	·2087100	·2089785	·2092468	2690
162	·2095150	·2097830	·2100508	·2103185	·2105860	·2108534	·2111205	·2113876	·2116544	·2119211	2673
163	·2121876	·2124540	·2127202	·2129862	·2132521	·2135178	·2137833	·2140487	·2143139	·2145790	2656
164	·2148438	·2151086	·2153732	·2156376	·2159018	·2161659	·2164298	·2166936	·2169572	·2172207	2640
165	·2174839	·2177471	·2180100	·2182729	·2185355	·2187980	·2190603	·2193225	·2195845	·2198464	2625
166	·2201081	·2203696	·2206310	·2208922	·2211533	·2214142	·2216750	·2219356	·2221960	·2224563	2609
167	·2227165	·2229764	·2232363	·2234959	·2237555	·2240148	·2242740	·2245331	·2247920	·2250507	2593
168	·2253093	·2255677	·2258260	·2260841	·2263421	·2265999	·2268576	·2271151	·2273724	·2276296	2578
169	·2278867	·2281436	·2284004	·2286570	·2289134	·2291697	·2294258	·2296818	·2299377	·2301934	2563
170	·2304489	·2307043	·2309596	·2312146	·2314696	·2317244	·2319790	·2322335	·2324879	·2327421	2548
171	·2329961	·2332500	·2335038	·2337574	·2340108	·2342641	·2345173	·2347703	·2350232	·2352759	2533
172	·2355284	·2357809	·2360331	·2362853	·2365373	·2367891	·2370408	·2372923	·2375437	·2377950	2518
173	·2380461	·2382971	·2385479	·2387986	·2390491	·2392995	·2395497	·2397998	·2400498	·2402996	2503
174	·2405492	·2407988	·2410482	·2412974	·2415465	·2417954	·2420442	·2422929	·2425414	·2427898	2489
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
75	·2430380	·2432861	·2435341	·2437819	·2440296	·2442771	·2445245	·2447718	·2450189	·2452658	2475
76	·2455127	·2457594	·2460059	·2462523	·2464986	·2467447	·2469907	·2472365	·2474823	·2477278	2461
77	·2479733	·2482186	·2484637	·2487087	·2489536	·2491984	·2494430	·2496874	·2499318	·2501759	2447
78	·2504200	·2506639	·2509077	·2511513	·2513949	·2516382	·2518815	·2521246	·2523675	·2526103	2433
79	·2528530	·2530956	·2533380	·2535803	·2538224	·2540645	·2543063	·2545481	·2547897	·2550312	2419
80	·2552725	·2555137	·2557548	·2559957	·2562365	·2564772	·2567177	·2569582	·2571984	·2574386	2406
81	·2576786	·2579185	·2581582	·2583978	·2586373	·2588766	·2591158	·2593549	·2595939	·2598327	2393
82	·2600714	·2603099	·2605484	·2607867	·2610248	·2612629	·2615008	·2617385	·2619762	·2622137	2379
83	·2624511	·2626883	·2629255	·2631625	·2633993	·2636361	·2638727	·2641092	·2643455	·2645817	2367
84	·2648178	·2650538	·2652896	·2655253	·2657609	·2659964	·2662317	·2664669	·2667020	·2669369	2354
85	·2671717	·2674064	·2676410	·2678754	·2681097	·2683439	·2685780	·2688119	·2690457	·2692794	2342
86	·2695129	·2697464	·2699797	·2702129	·2704459	·2706788	·2709116	·2711443	·2713769	·2716093	2329
87	·2718416	·2720738	·2723058	·2725378	·2727696	·2730013	·2732328	·2734643	·2736956	·2739268	2316
88	·2741578	·2743888	·2746196	·2748503	·2750809	·2753114	·2755417	·2757719	·2760020	·2762320	2304
89	·2764618	·2766915	·2769211	·2771506	·2773800	·2776092	·2778383	·2780673	·2782962	·2785250	2292
90	·2787536	·2789821	·2792105	·2794388	·2796669	·2798950	·2801229	·2803507	·2805784	·2808059	2280
91	·2810334	·2812607	·2814879	·2817150	·2819419	·2821688	·2823955	·2826221	·2828486	·2830750	2268
92	·2833012	·2835274	·2837534	·2839793	·2842051	·2844307	·2846563	·2848817	·2851070	·2853322	2257
93	·2855573	·2857823	·2860071	·2862319	·2864565	·2866810	·2869054	·2871296	·2873538	·2875778	2244
94	·2878017	·2880255	·2882492	·2884728	·2886963	·2889196	·2891428	·2893660	·2895890	·2898118	2233
95	·2900346	·2902573	·2904798	·2907022	·2909246	·2911468	·2913689	·2915908	·2918127	·2920344	2221
96	·2922561	·2924776	·2926990	·2929203	·2931415	·2933626	·2935835	·2938044	·2940251	·2942457	2211
97	·2944662	·2946866	·2949069	·2951271	·2953471	·2955671	·2957869	·2960067	·2962263	·2964458	2199
98	·2966652	·2968845	·2971037	·2973227	·2975417	·2977605	·2979792	·2981979	·2984164	·2986348	2188
99	·2988531	·2990713	·2992893	·2995073	·2997252	·2999429	·3001605	·3003781	·3005955	·3008128	2177
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·3010300	·3012471	·3014641	·3016809	·3018977	·3021144	·3023309	·3025474	·3027637	·3029799	2167
01	·3031961	·3034121	·3036280	·3038438	·3040595	·3042751	·3044905	·3047059	·3049212	·3051363	2156
02	·3053514	·3055663	·3057812	·3059959	·3062105	·3064250	·3066394	·3068537	·3070680	·3072820	2145
03	·3074960	·3077099	·3079237	·3081374	·3083509	·3085644	·3087778	·3089910	·3092042	·3094172	2135
04	·3096302	·3098430	·3100557	·3102684	·3104809	·3106933	·3109056	·3111178	·3113300	·3115420	2124
05	·3117539	·3119657	·3121774	·3123889	·3126004	·3128118	·3130231	·3132343	·3134454	·3136563	2114
06	·3138672	·3140780	·3142887	·3144992	·3147097	·3149201	·3151303	·3153405	·3155505	·3157605	2103
07	·3159703	·3161801	·3163898	·3165993	·3168088	·3170181	·3172273	·3174365	·3176455	·3178545	2093
08	·3180633	·3182721	·3184807	·3186893	·3188977	·3191061	·3193143	·3195224	·3197305	·3199384	2083
09	·3201463	·3203540	·3205617	·3207692	·3209767	·3211840	·3213913	·3215984	·3218055	·3220124	2073
10	·3222193	·3224261	·3226327	·3228393	·3230457	·3232521	·3234584	·3236645	·3238706	·3240766	2063
11	·3242825	·3244882	·3246939	·3248995	·3251050	·3253104	·3255157	·3257209	·3259260	·3261310	2053
12	·3263359	·3265407	·3267454	·3269500	·3271545	·3273589	·3275633	·3277675	·3279716	·3281757	2044
13	·3283796	·3285834	·3287872	·3289909	·3291944	·3293979	·3296012	·3298045	·3300077	·3302108	2034
14	·3304138	·3306167	·3308195	·3310222	·3312248	·3314273	·3316297	·3318320	·3320343	·3322364	2025
15	·3324385	·3326404	·3328423	·3330440	·3332457	·3334473	·3336488	·3338501	·3340514	·3342526	2016
16	·3344538	·3346548	·3348557	·3350565	·3352573	·3354579	·3356585	·3358589	·3360593	·3362596	2006
17	·3364597	·3366598	·3368598	·3370597	·3372595	·3374593	·3376589	·3378584	·3380579	·3382572	1997
18	·3384565	·3386557	·3388547	·3390537	·3392526	·3394514	·3396502	·3398488	·3400473	·3402458	1987
19	·3404441	·3406424	·3408405	·3410386	·3412366	·3414345	·3416323	·3418301	·3420277	·3422252	1979
20	·3424227	·3426200	·3428173	·3430145	·3432116	·3434086	·3436055	·3438023	·3439991	·3441957	1970
21	·3443923	·3445887	·3447851	·3449814	·3451776	·3453737	·3455698	·3457657	·3459615	·3461573	1961
22	·3463530	·3465486	·3467441	·3469395	·3471348	·3473300	·3475252	·3477202	·3479152	·3481101	1952
23	·3483049	·3484996	·3486942	·3488887	·3490832	·3492775	·3494718	·3496660	·3498601	·3500541	1943
24	·3502480	·3504419	·3506356	·3508293	·3510229	·3512163	·3514098	·3516031	·3517963	·3519895	1934
No.	0	1	2	3	4	5	6	7	8	9	Diff.

o.	0	1	2	3	4	5	6	7	8	9	Diff.
25	·3521825	·3523755	·3525684	·3527612	·3529539	·3531465	·3533391	·3535316	·3537239	·3539162	1926
26	·3541084	·3543006	·3544926	·3546846	·3548764	·3550682	·3552599	·3554515	·3556431	·3558345	1918
27	·3560259	·3562171	·3564083	·3565994	·3567905	·3569814	·3571723	·3573630	·3575537	·3577443	1910
28	·3579348	·3581253	·3583156	·3585059	·3586961	·3588862	·3590762	·3592662	·3594560	·3596458	1900
29	·3598355	·3600251	·3602146	·3604041	·3605934	·3607827	·3609719	·3611610	·3613500	·3615390	1893
30	·3617278	·3619166	·3621053	·3622939	·3624825	·3626709	·3628593	·3630476	·3632358	·3634239	1884
31	·3636120	·3637999	·3639878	·3641756	·3643634	·3645510	·3647386	·3649260	·3651134	·3653007	1876
32	·3654880	·3656751	·3658622	·3660492	·3662361	·3664230	·3666097	·3667964	·3669830	·3671695	1868
33	·3673559	·3675423	·3677285	·3679147	·3681009	·3682869	·3684728	·3686587	·3688445	·3690302	1860
34	·3692159	·3694014	·3695869	·3697723	·3699576	·3701428	·3703280	·3705131	·3706981	·3708830	1852
35	·3710679	·3712526	·3714373	·3716219	·3718065	·3719909	·3721753	·3723596	·3725438	·3727279	1845
36	·3729120	·3730960	·3732799	·3734637	·3736475	·3738311	·3740147	·3741983	·3743817	·3745651	1836
37	·3747483	·3749316	·3751147	·3752977	·3754807	·3756636	·3758464	·3760292	·3762119	·3763944	1829
38	·3765770	·3767594	·3769418	·3771240	·3773063	·3774884	·3776704	·3778524	·3780343	·3782161	1821
39	·3783979	·3785796	·3787612	·3789427	·3791241	·3793055	·3794868	·3796680	·3798492	·3800302	1813
40	·3802112	·3803922	·3805730	·3807538	·3809345	·3811151	·3812956	·3814761	·3816565	·3818368	1806
41	·3820170	·3821972	·3823773	·3825573	·3827373	·3829171	·3830969	·3832767	·3834563	·3836359	1799
42	·3838154	·3839948	·3841741	·3843534	·3845326	·3847117	·3848908	·3850698	·3852487	·3854275	1791
43	·3856063	·3857850	·3859636	·3861421	·3863206	·3864990	·3866773	·3868555	·3870337	·3872118	1784
44	·3873898	·3875678	·3877457	·3879235	·3881012	·3882789	·3884565	·3886340	·3888114	·3889888	1776
45	·3891661	·3893433	·3895205	·3896975	·3898746	·3900515	·3902284	·3904052	·3905819	·3907585	1770
46	·3909351	·3911116	·3912880	·3914644	·3916407	·3918169	·3919931	·3921691	·3923452	·3925211	1762
47	·3926970	·3928727	·3930485	·3932241	·3933997	·3935752	·3937506	·3939260	·3941013	·3942765	1755
48	·3944517	·3946268	·3948018	·3949767	·3951516	·3953264	·3955011	·3956758	·3958504	·3960249	1748
49	·3961993	·3963737	·3965480	·3967223	·3968964	·3970705	·3972446	·3974185	·3975924	·3977663	1741
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
50	·3979400	·3981137	·3982873	·3984608	·3986343	·3988077	·3989811	·3991543	·3993275	·3995007	1734
51	·3996737	·3998467	·4000196	·4001925	·4003653	·4005380	·4007106	·4008832	·4010557	·4012282	1727
52	·4014005	·4015728	·4017451	·4019173	·4020894	·4022614	·4024333	·4026052	·4027771	·4029488	1720
53	·4031205	·4032921	·4034637	·4036352	·4038066	·4039780	·4041492	·4043205	·4044916	·4046627	1713
54	·4048337	·4050047	·4051755	·4053464	·4055171	·4056878	·4058584	·4060289	·4061994	·4063698	1706
55	·4065402	·4067105	·4068807	·4070508	·4072209	·4073909	·4075608	·4077307	·4079005	·4080703	1700
56	·4082400	·4084096	·4085791	·4087486	·4089180	·4090874	·4092567	·4094259	·4095950	·4097641	1693
57	·4099331	·4101021	·4102710	·4104398	·4106085	·4107772	·4109459	·4111144	·4112829	·4114513	1687
58	·4116197	·4117880	·4119562	·4121244	·4122925	·4124605	·4126285	·4127964	·4129643	·4131321	1680
59	·4132998	·4134674	·4136350	·4138025	·4139700	·4141374	·4143047	·4144719	·4146391	·4148063	1674
60	·4149733	·4151404	·4153073	·4154742	·4156410	·4158077	·4159744	·4161410	·4163076	·4164741	1667
61	·4166405	·4168069	·4169732	·4171394	·4173056	·4174717	·4176377	·4178037	·4179696	·4181355	1661
62	·4183013	·4184670	·4186327	·4187983	·4189638	·4191293	·4192947	·4194601	·4196254	·4197906	1655
63	·4199557	·4201208	·4202859	·4204509	·4206158	·4207806	·4209454	·4211101	·4212748	·4214394	1648
64	·4216039	·4217684	·4219328	·4220972	·4222615	·4224257	·4225898	·4227539	·4229180	·4230820	1642
65	·4232459	·4234097	·4235735	·4237372	·4239009	·4240645	·4242281	·4243916	·4245550	·4247183	1636
66	·4248816	·4250449	·4252081	·4253712	·4255342	·4256972	·4258601	·4260230	·4261858	·4263486	1630
67	·4265113	·4266739	·4268365	·4269990	·4271614	·4273238	·4274861	·4276484	·4278106	·4279727	1623
68	·4281348	·4282968	·4284588	·4286207	·4287825	·4289443	·4291060	·4292677	·4294293	·4295908	1618
69	·4297523	·4299137	·4300751	·4302364	·4303976	·4305588	·4307199	·4308809	·4310419	·4312029	1611
70	·4313638	·4315246	·4316853	·4318460	·4320067	·4321673	·4323278	·4324883	·4326487	·4328090	1606
71	·4329693	·4331295	·4332897	·4334498	·4336098	·4337698	·4339298	·4340896	·4342495	·4344092	1600
72	·4345689	·4347285	·4348881	·4350476	·4352071	·4353665	·4355259	·4356851	·4358444	·4360035	1594
73	·4361626	·4363217	·4364807	·4366396	·4367985	·4369573	·4371161	·4372748	·4374334	·4375920	1588
74	·4377506	·4379090	·4380675	·4382258	·4383841	·4385423	·4387005	·4388587	·4390167	·4391747	1582
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
75	·4393327	·4394906	·4396484	·4398062	·4399639	·4401216	·4402792	·4404368	·4405943	·4407517	1577
76	·4409091	·4410664	·4412237	·4413809	·4415380	·4416951	·4418522	·4420092	·4421661	·4423230	1571
77	·4424798	·4426365	·4427932	·4429499	·4431065	·4432630	·4434195	·4435759	·4437322	·4438885	1565
78	·4440448	·4442010	·4443571	·4445132	·4446692	·4448252	·4449811	·4451370	·4452928	·4454485	1560
79	·4456042	·4457598	·4459154	·4460709	·4462264	·4463818	·4465372	·4466925	·4468477	·4470029	1554
80	·4471580	·4473131	·4474681	·4476231	·4477780	·4479329	·4480877	·4482424	·4483971	·4485517	1548
81	·4487063	·4488608	·4490153	·4491697	·4493241	·4494784	·4496327	·4497868	·4499410	·4500951	1543
82	·4502491	·4504031	·4505570	·4507109	·4508647	·4510185	·4511722	·4513258	·4514794	·4516329	1537
83	·4517864	·4519399	·4520932	·4522466	·4523998	·4525531	·4527062	·4528593	·4530124	·4531654	1532
84	·4533183	·4534712	·4536241	·4537769	·4539296	·4540823	·4542349	·4543875	·4545400	·4546924	1526
85	·4548449	·4549972	·4551495	·4553018	·4554540	·4556061	·4557582	·4559102	·4560622	·4562142	1522
86	·4563660	·4565179	·4566696	·4568213	·4569730	·4571246	·4572762	·4574277	·4575791	·4577305	1516
87	·4578819	·4580332	·4581844	·4583356	·4584868	·4586378	·4587889	·4589399	·4590908	·4592417	1511
88	·4593925	·4595433	·4596940	·4598446	·4599953	·4601458	·4602963	·4604468	·4605972	·4607475	1505
89	·4608978	·4610481	·4611983	·4613484	·4614985	·4616486	·4617986	·4619485	·4620984	·4622482	1501
90	·4623980	·4625477	·4626974	·4628470	·4629966	·4631461	·4632956	·4634450	·4635944	·4637437	1495
91	·4638930	·4640422	·4641914	·4643405	·4644895	·4646386	·4647875	·4649364	·4650853	·4652341	1489
92	·4653829	·4655316	·4656802	·4658288	·4659774	·4661259	·4662743	·4664227	·4665711	·4667194	1485
93	·4668676	·4670158	·4671640	·4673121	·4674601	·4676081	·4677561	·4679039	·4680518	·4681996	1480
94	·4683473	·4684950	·4686427	·4687903	·4689378	·4690853	·4692327	·4693801	·4695275	·4696748	1475
95	·4698220	·4699692	·4701164	·4702634	·4704105	·4705575	·4707044	·4708513	·4709982	·4711450	1470
96	·4712917	·4714384	·4715851	·4717317	·4718782	·4720247	·4721711	·4723175	·4724639	·4726102	1465
97	·4727564	·4729027	·4730488	·4731949	·4733410	·4734870	·4736329	·4737788	·4739247	·4740705	1460
98	·4742163	·4743620	·4745076	·4746533	·4747988	·4749443	·4750898	·4752352	·4753806	·4755259	1455
99	·4756712	·4758164	·4759616	·4761067	·4762518	·4763968	·4765418	·4766867	·4768316	·4769765	1450
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·4771213	·4772660	·4774107	·4775553	·4776999	·4778445	·4779890	·4781334	·4782778	·4784222	1445
01	·4785665	·4787108	·4788550	·4789991	·4791432	·4792873	·4794313	·4795753	·4797192	·4798631	1440
02	·4800069	·4801507	·4802945	·4804381	·4805818	·4807254	·4808689	·4810124	·4811559	·4812993	1436
03	·4814426	·4815859	·4817292	·4818724	·4820156	·4821587	·4823018	·4824448	·4825878	·4827307	1431
04	·4828736	·4830164	·4831592	·4833020	·4834446	·4835873	·4837299	·4838725	·4840150	·4841574	1426
05	·4842998	·4844422	·4845845	·4847268	·4848690	·4850112	·4851533	·4852954	·4854375	·4855795	1422
06	·4857214	·4858633	·4860052	·4861470	·4862888	·4864305	·4865722	·4867138	·4868554	·4869969	1417
07	·4871384	·4872798	·4874212	·4875626	·4877039	·4878451	·4879863	·4881275	·4882686	·4884097	1412
08	·4885507	·4886917	·4888326	·4889735	·4891144	·4892552	·4893959	·4895366	·4896773	·4898179	1408
09	·4899585	·4900990	·4902395	·4903799	·4905203	·4906607	·4908010	·4909412	·4910814	·4912216	1403
10	·4913617	·4915018	·4916418	·4917818	·4919217	·4920616	·4922015	·4923413	·4924810	·4926207	1398
11	·4927604	·4929000	·4930396	·4931791	·4933186	·4934581	·4935974	·4937368	·4938761	·4940154	1394
12	·4941546	·4942938	·4944329	·4945720	·4947110	·4948500	·4949890	·4951279	·4952667	·4954056	1390
13	·4955443	·4956831	·4958218	·4959604	·4960990	·4962375	·4963761	·4965145	·4966529	·4967913	1386
14	·4969296	·4970679	·4972062	·4973444	·4974825	·4976206	·4977587	·4978967	·4980347	·4981727	1381
15	·4983106	·4984484	·4985862	·4987240	·4988617	·4989994	·4991370	·4992746	·4994121	·4995496	1376
16	·4996871	·4998245	·4999619	·5000992	·5002365	·5003737	·5005109	·5006481	·5007852	·5009222	1372
17	·5010593	·5011962	·5013332	·5014701	·5016069	·5017437	·5018805	·5020172	·5021539	·5022905	1367
18	·5024271	·5025637	·5027002	·5028366	·5029731	·5031094	·5032458	·5033821	·5035183	·5036545	1364
19	·5037907	·5039268	·5040629	·5041989	·5043349	·5044709	·5046068	.5047426	·5048785	·5050142	1359
20	·5051500	·5052857	·5054213	·5055569	·5056925	·5058280	·5059635	·5060990	·5062344	·5063697	1355
21	·5065050	·5066403	·5067755	·5069107	·5070459	·5071810	·5073160	·5074511	·5075860	·5077210	1351
22	·5078559	·5079907	·5081255	·5082603	·5083950	·5085297	·5086644	·5087990	·5089335	·5090680	1347
23	·5092025	·5093370	·5094714	·5096057	·5097400	·5098743	·5100085	·5101427	·5102768	·5104109	1343
24	·5105450	·5106790	·5108130	·5109469	·5110808	·5112147	·5113485	·5114823	·5116160	·5117497	1338
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
325	·5118834	·5120170	·5121505	·5122841	·5124175	·5125510	·5126844	·5128178	·5129511	·5130844	1335
326	·5132176	·5133508	·5134840	·5136171	·5137502	·5138832	·5140162	·5141491	·5142820	·5144149	1330
327	·5145478	·5146805	·5148133	·5149460	·5150787	·5152113	·5153439	·5154764	·5156089	·5157414	1326
328	·5158738	·5160062	·5161386	·5162709	·5164031	·5165354	·5166676	·5167997	·5169318	·5170639	1323
329	·5171959	·5173279	·5174598	·5175917	·5177236	·5178554	·5179872	·5181189	·5182507	·5183823	1318
330	·5185139	·5186455	·5187771	·5189086	·5190400	·5191715	·5193028	·5194342	·5195655	·5196968	1314
331	·5198280	·5199592	·5200903	·5202214	·5203525	·5204835	·5206145	·5207455	·5208764	·5210073	1310
332	·5211381	·5212689	·5213996	·5215303	·5216610	·5217916	·5219222	·5220528	·5221833	·5223138	1306
333	·5224442	·5225746	·5227050	·5228353	·5229656	·5230958	·5232260	·5233562	·5234863	·5236164	1302
334	·5237465	·5238765	·5240064	·5241364	·5242663	·5243961	·5245259	·5246557	·5247854	·5249151	1299
335	·5250448	·5251744	·5253040	·5254336	·5255631	·5256925	·5258220	·5259513	·5260807	·5262100	1295
336	·5263393	·5264685	·5265977	·5267269	·5268560	·5269851	·5271141	·5272431	·5273721	·5275010	1291
337	·5276299	·5277588	·5278876	·5280163	·5281451	·5282738	·5284024	·5285311	·5286596	·5287882	1286
338	·5289167	·5290452	·5291736	·5293020	·5294304	·5295587	·5296870	·5298152	·5299434	·5300716	1283
339	·5301997	·5303278	·5304558	·5305839	·5307118	·5308398	·5309677	·5310955	·5312234	·5313512	1279
340	·5314789	·5316066	·5317343	·5318619	·5319896	·5321171	·5322446	·5323721	·5324996	·5326270	1275
341	·5327544	·5328817	·5330090	·5331363	·5332635	·5333907	·5335179	·5336450	·5337721	·5338991	1272
342	·5340261	·5341531	·5342800	·5344069	·5345338	·5346606	·5347874	·5349141	·5350408	·5351675	1268
343	·5352941	·5354207	·5355473	·5356738	·5358003	·5359267	·5360532	·5361795	·5363059	·5364322	1264
344	·5365584	·5366847	·5368109	·5369370	·5370631	·5371892	·5373153	·5374413	·5375673	·5376932	1260
345	·5378191	·5379450	·5380708	·5381966	·5383223	·5384481	·5385737	·5386994	·5388250	·5389506	1257
346	·5390761	·5392016	·5393271	·5394525	·5395779	·5397032	·5398286	·5399538	·5400791	·5402043	1254
347	·5403295	·5404546	·5405797	·5407048	·5408298	·5409548	·5410798	·5412047	·5413296	·5414544	1250
348	·5415792	·5417040	.5418288	·5419535	·5420781	·5422028	·5423274	·5424519	·5425765	·5427010	1246
349	·5428254	·5429498	·5430742	·5431986	·5433229	·5434472	·5435714	·5436956	·5438198	·5439439	1243
No.	0	1	2	3	4	5	6	7	8	9	Diff.

o.	0	1	2	3	4	5	6	7	8	9	Diff.
50	·5440680	·5441921	·5443161	·5444401	·5445641	·5446880	·5448119	·5449358	·5450596	·5451834	1239
51	·5453071	·5454308	·5455545	·5456781	·5458018	·5459253	·5460489	·5461724	·5462958	·5464193	1235
52	·5465427	·5466660	·5467894	·5469126	·5470359	·5471591	·5472823	·5474055	·5475286	·5476517	1232
53	·5477747	·5478977	·5480207	·5481436	·5482665	·5483894	·5485123	·5486351	·5487578	·5488806	1229
54	·5490033	·5491259	·5492486	·5493712	·5494937	·5496162	·5497387	·5498612	·5499836	·5501060	1225
55	·5502284	·5503507	·5504730	·5505952	·5507174	·5508396	·5509618	·5510839	·5512059	·5513280	1222
56	·5514500	·5515720	·5516939	·5518158	·5519377	·5520595	·5521813	·5523031	·5524248	·5525465	1219
57	·5526682	·5527899	·5529115	·5530330	·5531545	·5532760	·5533975	·5535189	·5536403	·5537617	1214
58	·5538830	·5540043	·5541256	·5542468	·5543680	·5544892	·5546103	·5547314	·5548524	·5549735	1211
59	·5550944	·5552154	·5553363	·5554572	·5555781	·5556989	·5558197	·5559404	·5560612	·5561818	1208
60	·5563025	·5564231	·5565437	·5566643	·5567848	·5569053	·5570257	·5571461	·5572665	·5573869	1205
61	·5575072	·5576275	·5577477	·5578680	·5579881	·5581083	·5582284	·5583485	·5584686	·5585886	1202
62	·5587086	·5588285	·5589484	·5590683	·5591882	·5593080	·5594278	·5595476	·5596673	·5597870	1198
63	·5599066	·5600262	·5601458	·5602654	·5603849	·5605044	·5606239	·5607433	·5608627	·5609821	1195
64	·5611014	·5612207	·5613399	·5614592	·5615784	·5616975	·5618167	·5619358	·5620548	·5621739	1192
65	·5622929	·5624118	·5625308	·5626497	·5627685	·5628874	·5630062	·5631250	·5632437	·5633624	1188
66	·5634811	·5635997	·5637183	·5638369	·5639555	·5640740	·5641925	·5643109	·5644293	·5645477	1185
67	·5646661	·5647844	·5649027	·5650209	·5651392	·5652573	·5653755	·5654936	·5656117	·5657298	1182
68	·5658478	·5659658	·5660838	·5662017	·5663196	·5664375	·5665553	·5666731	·5667909	·5669087	1178
69	·5670264	·5671440	·5672617	·5673793	·5674969	·5676144	·5677320	·5678495	·5679669	·5680843	1176
70	·5682017	·5683191	·5684364	·5685537	·5686710	·5687882	·5689054	·5690226	·5691397	·5692568	1172
71	·5693739	·5694910	·5696080	·5697249	·5698419	·5699588	·5700757	·5701926	·5703094	·5704262	1169
72	·5705429	·5706597	·5707764	·5708930	·5710097	·5711263	·5712429	·5713594	·5714759	·5715924	1166
73	·5717088	·5718252	·5719416	·5720580	·5721743	·5722906	·5724069	·5725231	·5726393	·5727555	1163
74	·5728716	·5729877	·5731038	·5732198	·5733358	·5734518	·5735678	·5736837	·5737996	·5739154	1160
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
75	·5740313	·5741471	·5742628	·5743786	·5744943	·5746099	·5747256	·5748412	·5749568	·5750723	1157
76	·5751878	·5753033	·5754188	·5755342	·5756496	·5757650	·5758803	·5759956	·5761109	·5762261	1153
77	·5763414	·5764565	·5765717	·5766868	·5768019	·5769170	·5770320	·5771470	·5772620	·5773769	1151
78	·5774918	·5776067	·5777215	·5778363	·5779511	·5780659	·5781806	·5782953	·5784100	·5785246	1148
79	·5786392	·5787538	·5788683	·5789828	·5790973	·5792118	·5793262	·5794406	·5795550	·5796693	1145
80	·5797836	·5798979	·5800121	·5801263	·5802405	·5803547	·5804688	·5805829	·5806969	·5808110	1141
81	·5809250	·5810389	·5811529	·5812668	·5813807	·5814945	·5816084	·5817222	·5818359	·5819497	1139
82	·5820634	·5821770	·5822907	·5824043	·5825179	·5826314	·5827450	·5828585	·5829719	·5830854	1136
83	·5831988	·5833122	·5834255	·5835388	·5836521	·5837654	·5838786	·5839918	·5841050	·5842181	1133
84	·5843312	·5844443	·5845574	·5846704	·5847834	·5848963	·5850093	·5851222	·5852351	·5853479	1129
85	·5854607	·5855735	·5856863	·5857990	·5859117	·5860244	·5861370	·5862496	·5863622	·5864748	1126
86	·5865873	·5866998	·5868123	·5869247	·5870371	·5871495	·5872618	·5873742	·5874865	·5875987	1123
87	·5877110	·5878232	·5879353	·5880475	·5881596	·5882717	·5883838	·5884958	·5886078	·5887198	1120
88	·5888317	·5889436	·5890555	·5891674	·5892792	·5893910	·5895028	·5896145	·5897263	·5898379	1117
89	·5899496	·5900612	·5901728	·5902844	·5903959	·5905075	·5906189	·5907304	·5908418	·5909532	1115
90	·5910646	·5911760	·5912873	·5913986	·5915098	·5916210	·5917322	·5918434	·5919546	·5920657	1112
91	·5921768	·5922878	·5923988	·5925098	·5926208	·5927318	·5928427	·5929536	·5930644	·5931753	1109
92	·5932861	·5933968	·5935076	·5936183	·5937290	·5938397	·5939503	·5940609	·5941715	·5942820	1106
93	·5943926	·5945030	·5946135	·5947239	·5948344	·5949447	·5950551	·5951654	·5952757	·5953860	1104
94	·5954962	·5956064	·5957166	·5958268	·5959369	·5960470	·5961571	·5962671	·5963771	·5964871	1100
95	·5965971	·5967070	·5968169	·5969268	·5970367	·5971465	·5972563	·5973661	·5974758	·5975855	1098
96	·5976952	·5978048	·5979145	·5980241	·5981336	·5982432	·5983527	·5984622	·5985717	·5986811	1095
97	·5987905	·5988999	·5990092	·5991186	·5992279	·5993371	·5994464	·5995556	·5996648	·5997739	1092
98	·5998831	·5999922	·6001013	·6002103	·6003193	·6004283	·6005373	·6006462	·6007551	·6008640	1090
99	·6009729	·6010817	·6011905	·6012993	·6014081	·6015168	·6016255	·6017341	·6018428	·6019514	1087
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·6020600	·6021686	·6022771	·6023856	·6024941	·6026025	·6027109	·6028193	·6029277	·6030361	1084
01	·6031444	·6032527	·6033609	·6034692	·6035774	·6036855	·6037937	·6039018	·6040099	·6041180	1082
02	·6042261	·6043341	·6044421	·6045500	·6046580	·6047659	·6048738	·6049816	·6050895	·6051973	1079
03	·6053050	·6054128	·6055205	·6056282	·6057359	·6058435	·6059512	·6060587	·6061663	·6062739	1076
04	·6063814	·6064889	·6065963	·6067037	·6068111	·6069185	·6070259	·6071332	·6072405	·6073478	1074
05	·6074550	·6075622	·6076694	·6077766	·6078837	·6079909	·6080979	·6082050	·6083120	·6084191	1071
06	·6085260	·6086330	·6087399	·6088468	·6089537	·6090605	·6091674	·6092742	·6093809	·6094877	1069
07	·6095944	·6097011	·6098078	·6099144	·6100210	·6101276	·6102342	·6103407	·6104472	·6105537	1065
08	·6106602	·6107666	·6108730	·6109794	·6110857	·6111921	·6112984	·6114046	·6115109	·6116171	1063
09	·6117233	·6118295	·6119356	·6120417	·6121478	·6122539	·6123599	·6124660	·6125720	·6126779	1060
10	·6127839	·6128898	·6129957	·6131015	·6132074	·6133132	·6134189	·6135247	·6136304	·6137361	1058
11	·6138418	·6139475	·6140531	·6141587	·6142643	·6143698	·6144754	·6145809	·6146863	·6147918	1056
12	·6148972	·6150026	·6151080	·6152133	·6153187	·6154240	·6155292	·6156345	·6157397	·6158449	1053
13	·6159501	·6160552	·6161603	·6162654	·6163705	·6164755	·6165805	·6166855	·6167905	·6168954	1050
14	·6170003	·6171052	·6172101	·6173149	·6174197	·6175245	·6176293	·6177340	·6178387	·6179434	1047
15	·6180481	·6181527	·6182573	·6183619	·6184665	·6185710	·6186755	·6187800	·6188845	·6189889	1045
16	·6190933	·6191977	·6193021	·6194064	·6195107	·6196150	·6197193	·6198235	·6199277	·6200319	1043
17	·6201361	·6202402	·6203443	·6204484	·6205524	·6206565	·6207605	·6208645	·6209684	·6210724	1040
18	·6211763	·6212802	·6213840	·6214879	·6215917	·6216955	·6217992	·6219030	·6220067	·6221104	1038
19	·6222140	·6223177	·6224213	·6225249	·6226284	·6227320	·6228355	·6229390	·6230424	·6231459	1036
20	·6232493	·6233527	·6234560	·6235594	·6236627	·6237660	·6238693	·6239725	·6240757	·6241789	1033
21	·6242821	·6243852	·6244884	·6245915	·6246945	·6247976	·6249006	·6250036	·6251066	·6252095	1030
22	·6253125	·6254154	·6255182	·6256211	·6257239	·6258267	·6259295	·6260322	·6261350	·6262377	1028
23	·6263404	·6264430	·6265457	·6266483	·6267509	·6268534	·6269560	·6270585	·6271610	·6272634	1025
24	·6273659	·6274683	·6275707	·6276730	·6277754	·6278777	·6279800	·6280823	·6281845	·6282867	1023
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
425	·6283889	·6284911	·6285933	·6286954	·6287975	·6288996	·6290016	·6291037	·6292057	·6293076	1021
426	·6294096	·6295115	·6296134	·6297153	·6298172	·6299190	·6300209	·6301226	·6302244	·6303262	1019
427	·6304279	·6305296	·6306312	·6307329	·6308345	·6309361	·6310377	·6311393	·6312408	·6313423	1016
428	·6314438	·6315452	·6316467	·6317481	·6318495	·6319508	·6320522	·6321535	·6322548	·6323560	1014
429	·6324573	·6325585	·6326597	·6327609	·6328620	·6329632	·6330643	·6331654	·6332664	·6333674	1011
430	·6334685	·6335694	·6336704	·6337713	·6338723	·6339732	·6340740	·6341749	·6342757	·6343765	1009
431	·6344773	·6345780	·6346788	·6347795	·6348801	·6349808	·6350814	·6351820	·6352826	·6353832	1007
432	·6354837	·6355843	·6356848	·6357852	·6358857	·6359861	·6360865	·6361869	·6362873	·6363876	1004
433	·6364879	·6365882	·6366884	6367887	·6368889	·6369891	·6370893	·6371894	·6372895	·6373897	1002
434	·6374897	·6375898	·6376898	·6377898	·6378898	·6379898	·6380897	·6381896	·6382895	·6383894	1000
435	·6384893	·6385891	·6386889	·6387887	·6388884	·6389882	·6390879	·6391876	·6392872	·6393869	997
436	·6394865	·6395861	·6396857	·6397852	·6398847	·6399842	·6400837	·6401832	·6402826	·6403820	995
437	·6404814	·6405808	·6406802	·6407795	·6408788	·6409781	·6410773	·6411765	·6412758	·6413749	993
438	·6414741	·6415733	·6416724	·6417715	·6418705	·6419696	·6420686	·6421676	·6422666	·6423656	990
439	·6424645	·6425634	·6426623	·6427612	·6428601	·6429589	·6430577	·6431565	·6432552	·6433540	988
440	·6434527	·6435514	·6436500	·6437487	·6438473	·6439459	·6440445	·6441431	·6442416	·6443401	985
441	·6444386	·6445371	·6446355	·6447339	·6448323	·6449307	·6450291	·6451274	·6452257	·6453240	984
442	·6454223	·6455205	·6456187	·6457169	·6458151	·6459133	·6460114	·6461095	·6462076	·6463057	981
443	·6464037	·6465018	·6465998	·6466977	·6467957	·6468936	·6469915	·6470894	·6471873	·6472851	979
444	·6473830	·6474808	·6475786	·6476763	·6477741	·6478718	·6479695	·6480671	·6481648	·6482624	977
445	·6483600	·6484576	·6485552	·6486527	·6487502	·6488477	·6489452	·6490426	·6491401	·6492375	975
446	·6493349	·6494322	·6495296	·6496269	·6497242	·6498215	·6499187	·6500160	·6501132	·6502104	973
447	·6503075	·6504047	·6505018	·6505989	·6506960	·6507930	·6508901	·6509871	·6510841	·6511811	971
448	·6512780	·6513749	·6514719	·6515687	·6516656	·6517624	·6518593	·6519561	·6520528	·6521496	969
449	·6522463	·6523431	·6524397	·6525364	·6526331	·6527297	·6528263	·6529229	·6530195	·6531160	966
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
50	·6532125	·6533090	·6534055	·6535019	·6535984	·6536948	·6537912	·6538876	·6539839	·6540802	965
51	·6541765	·6542728	·6543691	·6544653	·6545616	·6546578	·6547539	·6548501	·6549462	·6550423	962
52	·6551384	·6552345	·6553306	·6554266	·6555226	·6556186	·6557145	·6558105	·6559064	·6560023	960
53	·6560982	·6561941	·6562899	·6563857	·6564815	·6565773	·6566730	·6567688	·6568645	·6569602	958
54	·6570559	·6571515	·6572471	·6573427	·6574383	·6575339	·6576294	·6577250	·6578205	·6579159	955
55	·6580114	·6581068	·6582023	·6582977	·6583930	·6584884	·6585837	·6586790	·6587743	·6588696	953
56	·6589648	·6590601	·6591553	·6592505	·6593456	·6594408	·6595359	·6596310	·6597261	·6598212	951
57	·6599162	·6600112	·6601062	·6602012	·6602962	·6603911	·6604860	·6605809	·6606758	·6607706	950
58	·6608655	·6609603	·6610551	·6611499	·6612446	·6613393	·6614341	·6615287	·6616234	·6617181	947
59	·6618127	·6619073	·6620019	·6620964	·6621910	·6622855	·6623800	·6624745	·6625690	·6626634	945
60	·6627578	·6628522	·6629466	·6630410	·6631353	·6632296	·6633239	·6634182	·6635125	·6636067	944
61	·6637009	·6637951	·6638893	·6639835	·6640776	·6641717	·6642658	·6643599	·6644539	·6645480	941
62	·6646420	·6647360	·6648299	·6649239	·6650178	·6651117	·6652056	·6652995	·6653934	·6654872	939
63	·6655810	·6656748	·6657686	·6658623	·6659560	·6660497	·6661434	·6662371	·6663307	·6664244	937
64	·6665180	·6666116	·6667051	·6667987	·6668922	·6669857	·6670792	·6671727	·6672661	·6673595	935
65	·6674530	·6675463	·6676397	·6677331	·6678264	·6679197	·6680130	·6681062	·6681995	·6682927	933
66	·6683859	·6684791	·6685723	·6686654	·6687586	·6688516	·6689447	·6690378	·6691308	·6692239	931
67	·6693169	·6694099	·6695028	·6695958	·6696887	·6697816	·6698745	·6699674	·6700602	·6701530	929
68	·6702459	·6703386	·6704314	·6705242	·6706169	·6707096	·6708023	·6708950	·6709876	·6710802	927
69	·6711728	·6712654	·6713580	·6714506	·6715431	·6716356	·6717281	·6718206	·6719130	·6720054	925
70	·6720979	·6721903	·6722826	·6723750	·6724673	·6725596	·6726519	·6727442	·6728365	·6729287	923
71	·6730209	·6731131	·6732053	·6732974	·6733896	·6734817	·6735738	·6736659	·6737579	·6738500	921
72	·6739420	·6740340	·6741260	·6742179	·6743099	·6744018	·6744937	·6745856	·6746775	·6747693	919
73	·6748611	·6749529	·6750447	·6751365	·6752283	·6753200	·6754117	·6755034	·6755951	·6756867	918
74	·6757783	·6758700	·6759615	·6760531	·6761447	·6762362	·6763277	·6764192	·6765107	·6766022	915
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
475	·6766936	·6767850	·6768764	·6769678	·6770592	·6771505	·6772418	·6773332	·6774244	·6775157	913
476	·6776070	·6776982	·6777894	·6778806	·6779718	·6780629	·6781540	·6782452	·6783362	·6784273	912
477	·6785184	·6786094	·6787004	·6787914	·6788824	·6789734	·6790643	·6791552	·6792461	·6793370	910
478	·6794279	·6795187	·6796096	·6797004	·6797912	·6798819	·6799727	·6800634	·6801541	·6802448	907
479	·6803355	·6804262	·6805168	·6806074	·6806980	·6807886	·6808792	·6809697	·6810602	·6811507	905
480	·6812412	·6813317	·6814222	·6815126	·6816030	·6816934	·6817838	·6818741	·6819645	·6820548	903
481	·6821451	·6822354	·6823256	·6824159	·6825061	·6825963	·6826865	·6827766	·6828668	·6829569	902
482	·6830470	·6831371	·6832272	·6833173	·6834073	·6834973	·6835873	·6836773	·6837673	·6838572	900
483	·6839471	·6840370	·6841269	·6842168	·6843066	·6843965	·6844863	·6845761	·6846659	·6847556	898
484	·6848454	·6849351	·6850248	·6851145	·6852041	·6852938	·6853834	·6854730	·6855626	·6856522	896
485	·6857417	·6858313	·6859208	·6860103	·6860998	·6861892	·6862787	·6863681	·6864575	·6865469	894
486	·6866363	·6867256	·6868150	·6869043	·6869936	·6870828	·6871721	·6872613	·6873506	·6874398	893
487	·6875290	·6876181	·6877073	·6877964	·6878855	·6879746	·6880637	·6881528	·6882418	·6883308	891
488	·6884198	·6885088	·6885978	·6886867	·6887757	·6888646	·6889535	·6890423	·6891312	·6892200	889
489	·6893089	·6893977	·6894864	·6895752	·6896640	·6897527	·6898414	·6899301	·6900188	·6901074	887
490	·6901961	·6902847	·6903733	·6904619	·6905505	·6906390	·6907275	·6908161	·6909046	·6909930	885
491	·6910815	·6911699	·6912584	·6913468	·6914352	·6915235	·6916119	·6917002	·6917885	·6918768	884
492	·6919651	·6920534	·6921416	·6922298	·6923180	·6924062	·6924944	·6925826	·6926707	·6927588	882
493	·6928469	·6929350	·6930231	·6931111	·6931991	·6932872	·6933752	·6934631	·6935511	·6936390	880
494	·6937269	·6938149	·6939027	·6939906	·6940785	·6941663	·6942541	·6943419	·6944297	·6945175	878
495	·6946052	·6946929	·6947806	·6948683	·6949560	·6950437	·6951313	·6952189	·6953065	·6953941	876
496	·6954817	·6955692	·6956568	·6957443	·6958318	·6959193	·6960067	·6960942	·6961816	·6962690	874
497	·6963564	·6964438	·6965311	·6966185	·6967058	·6967931	·6968804	·6969676	·6970549	·6971421	873
498	·6972293	·6973165	·6974037	·6974909	·6975780	·6976652	·6977523	·6978394	·6979264	·6980135	871
499	·6981005	·6981876	·6982746	·6983616	·6984485	·6985355	·6986224	·6987093	·6987963	·6988831	870
No.	0	1	2	3	4	5	6	7	8	9	Diff.

o.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·6989700	·6990569	·6991437	·6992305	·6993173	·6994041	·6994908	·6995776	·6996643	·6997510	868
01	·6998377	·6999244	·7000111	·7000977	·7001843	·7002709	·7003575	·7004441	·7005307	·7006172	866
02	·7007037	·7007902	·7008767	·7009632	·7010496	·7011361	·7012225	·7013089	·7013953	·7014816	864
03	·7015680	·7016543	·7017406	·7018269	·7019132	·7019995	·7020857	·7021720	·7022582	·7023444	863
04	·7024305	·7025167	·7026028	·7026890	·7027751	·7028612	·7029472	·7030333	·7031193	·7032054	861
05	·7032914	·7033774	·7034633	·7035493	·7036352	·7037212	·7038071	·7038930	·7039788	·7040647	859
06	·7041505	·7042363	·7043221	·7044079	·7044937	·7045794	·7046652	·7047509	·7048366	·7049223	857
07	·7050080	·7050936	·7051792	·7052649	·7053505	·7054360	·7055216	·7056072	·7056927	·7057782	856
08	·7058637	·7059492	·7060347	·7061201	·7062055	·7062910	·7063764	·7064617	·7065471	·7066325	854
09	·7067178	·7068031	·7068884	·7069737	·7070589	·7071442	·7072294	·7073146	·7073998	·7074850	852
10	·7075702	·7076553	·7077405	·7078256	·7079107	·7079957	·7080808	·7081659	·7082509	·7083359	851
11	·7084209	·7085059	·7085908	·7086758	·7087607	·7088456	·7089305	·7090154	·7091003	·7091851	849
12	·7092700	·7093548	·7094396	·7095244	·7096091	·7096939	·7097786	·7098633	·7099480	·7100327	848
13	·7101174	·7102020	·7102866	·7103713	·7104559	·7105404	·7106250	·7107096	·7107941	·7108786	846
14	·7109631	·7110476	·7111321	·7112165	·7113010	·7113854	·7114698	·7115542	·7116385	·7117229	844
15	·7118072	·7118915	·7119759	·7120601	·7121444	·7122287	·7123129	·7123971	·7124813	·7125655	843
16	·7126497	·7127339	·7128180	·7129021	·7129862	·7130703	·7131544	·7132385	·7133225	·7134065	840
17	·7134905	·7135745	·7136585	·7137425	·7138264	·7139104	·7139943	·7140782	·7141620	·7142459	839
18	·7143298	·7144136	·7144974	·7145812	·7146650	·7147488	·7148325	·7149162	·7150000	·7150837	838
19	·7151674	·7152510	·7153347	·7154183	·7155019	·7155856	·7156691	·7157527	·7158363	·7159198	836
20	·7160033	·7160869	·7161703	·7162538	·7163373	·7164207	·7165042	·7165876	·7166710	·7167544	834
21	·7168377	·7169211	·7170044	·7170877	·7171710	·7172543	·7173376	·7174208	·7175041	·7175873	833
22	·7176705	·7177537	·7178369	·7179200	·7180032	·7180863	·7181694	·7182525	·7183356	·7184186	831
23	·7185017	·7185847	·7186677	·7187507	·7188337	·7189167	·7189996	·7190826	·7191655	·7192484	830
24	·7193313	·7194142	·7194970	·7195799	·7196627	·7197455	·7198283	·7199111	·7199938	·7200766	828
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
525	·7201593	·7202420	·7203247	·7204074	·7204901	·7205727	·7206554	·7207380	·7208206	·7209032	827
526	·7219857	·7210683	·7211508	·7212334	·7213159	·7213984	·7214809	·7215633	·7216458	·7217282	825
527	·7218106	·7218930	·7219754	·7220578	·7221401	·7222225	·7223048	·7223871	·7224694	·7225517	823
528	·7226339	·7227162	·7227984	·7228806	·7229628	·7230450	·7231272	·7232093	·7232914	·7233736	822
529	·7234557	·7235378	·7236198	·7237019	·7237839	·7238660	·7239480	·7240300	·7241120	·7241939	821
530	·7242759	·7243578	·7244397	·7245216	·7246035	·7246854	·7247672	·7248491	·7249309	·7250127	819
531	·7250945	·7251763	·7252581	·7253398	·7254216	·7255033	·7255850	·7256667	·7257483	·7258300	817
532	·7259116	·7259933	·7260749	·7261565	·7262380	·7263196	·7264012	·7264827	·7265642	·7266457	815
533	·7267272	·7268087	·7268901	·7269716	·7270530	·7271344	·7272158	·7272972	·7273786	·7274599	814
534	·7275413	·7276226	·7277039	·7277852	·7278664	·7279477	·7280290	·7281102	·7281914	·7282726	812
535	·7283538	·7284350	·7285161	·7285972	·7286784	·7287595	·7288406	·7289216	·7290027	·7290838	811
536	·7291648	·7292458	·7293268	·7294078	·7294888	·7295697	·7296507	·7297316	·7298125	·7298934	809
537	·7299743	·7300552	·7301360	·7302168	·7302977	·7303785	·7304593	·7305400	·7306208	·7307015	808
538	·7307823	·7308630	·7309437	·7310244	·7311051	·7311857	·7312663	·7313470	·7314276	·7315082	807
539	·7315888	·7316693	·7317499	·7318304	·7319109	·7319914	·7320719	·7321524	·7322329	·7323133	805
540	·7323938	·7324742	·7325546	·7326350	·7327153	·7327957	·7328760	·7329564	·7330367	·7331170	803
541	·7331973	·7332775	·7333578	·7334380	·7335183	·7335985	·7336787	·7337588	·7338390	·7339192	802
542	·7339993	·7340794	·7341595	·7342396	·7343197	·7343997	·7344798	·7345598	·7346398	·7347198	801
543	·7347998	·7348798	·7349598	·7350397	·7351196	·7351995	·7352794	·7353593	·7354392	·7355191	799
544	·7355989	·7356787	·7357585	·7358383	·7359181	·7359979	·7360776	·7361574	·7362371	·7363168	798
545	·7363965	·7364762	·7365558	·7366355	·7367151	·7367948	·7368744	·7369540	·7370335	·7371131	796
546	·7371926	·7372722	·7373517	·7374312	·7375107	·7375902	·7376696	·7377491	·7378285	·7379079	795
547	·7379873	·7380667	·7381461	·7382254	·7383048	·7383841	·7384634	·7385427	·7386220	·7387013	794
548	·7387806	·7388598	·7389390	·7390182	·7390974	·7391766	·7392558	·7393350	·7394141	·7394932	792
549	·7395723	·7396514	·7397305	·7398096	·7398887	·7399677	·7400467	·7401257	·7402047	·7402837	790
No.	0	1	2	3	4	5	6	7	8	9	Diff.

o.	0	1	2	3	4	5	6	7	8	9	Diff.
50	·7403627	·7404416	·7405206	·7405995	·7406784	·7407573	·7408362	·7409151	·7409939	·7410728	789
51	·7411516	·7412304	·7413092	·7413880	·7414668	·7415455	·7416243	·7417030	·7417817	·7418604	787
52	·7419391	·7420177	·7420964	·7421750	·7422537	·7423323	·7424109	·7424895	·7425680	·7426466	786
53	·7427251	·7428037	·7428822	·7429607	·7430392	·7431176	·7431961	·7432745	·7433530	·7434314	785
54	·7435098	·7435882	·7436665	·7437449	·7438232	·7439016	·7439799	·7440582	·7441365	·7442147	783
55	·7442930	·7443712	·7444495	·7445277	·7446059	·7446841	·7447622	·7448404	·7449185	·7449967	782
56	·7450748	·7451529	·7452310	·7453091	·7453871	·7454652	·7455432	·7456212	·7456992	·7457772	781
57	·7458552	·7459332	·7460111	·7460890	·7461670	·7462449	·7463228	·7464006	·7464785	·7465564	779
58	·7466342	·7467120	·7467898	·7468676	·7469454	·7470232	·7471009	·7471787	·7472564	·7473341	778
59	·7474118	·7474895	·7475672	·7476448	·7477225	·7478001	·7478777	·7479553	·7480329	·7481105	776
60	·7481880	·7482656	·7483431	·7484206	·7484981	·7485756	·7486531	·7487306	·7488080	·7488854	775
61	·7489629	·7490403	·7491177	·7491950	·7492724	·7493498	·7494271	·7495044	·7495817	·7496590	773
62	·7497363	·7498136	·7498908	·7499681	·7500453	·7501225	·7501997	·7502769	·7503541	·7504312	772
63	·7505084	·7505855	·7506626	·7507398	·7508168	·7508939	·7509710	·7510480	·7511251	·7512021	770
64	·7512791	·7513561	·7514331	·7515101	·7515870	·7516639	·7517409	·7518178	·7518947	·7519716	769
65	·7520484	·7521253	·7522022	·7522790	·7523558	·7524326	·7525094	·7525862	·7526629	·7527397	768
66	·7528164	·7528932	·7529699	·7530466	·7531232	·7531999	·7532766	·7533532	·7534298	·7535065	767
67	·7535831	·7536596	·7537362	·7538128	·7538893	·7539659	·7540424	·7541189	·7541954	·7542719	766
68	·7543483	·7544248	·7545012	·7545777	·7546541	·7547305	·7548069	·7548832	·7549596	·7550359	764
69	·7551123	·7551886	·7552649	·7553412	·7554175	·7554937	·7555700	·7556462	·7557224	·7557987	762
70	·7558749	·7559510	·7560272	·7561034	·7561795	·7562556	·7563318	·7564079	·7564840	·7565600	761
71	·7566361	·7567122	·7567882	·7568642	·7569402	·7570162	·7570922	·7571682	·7572442	·7573201	760
72	·7573960	·7574719	·7575479	·7576237	·7576996	·7577755	·7578513	·7579272	·7580030	·7580788	758
73	·7581546	·7582304	·7583062	·7583819	·7584577	·7585334	·7586091	·7586848	·7587605	·7588362	757
74	·7589119	·7589875	·7590632	·7591388	·7592144	·7592900	·7593656	·7594412	·7595168	·7595923	756
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
575	·7596678	·7597434	·7598189	·7598944	·7599699	·7600453	·7601208	·7601962	·7602717	·7603471	755
576	·7604225	·7604979	·7605733	·7606486	·7607240	·7607993	·7608746	·7609500	·7610253	·7611005	753
577	·7611758	·7612511	·7613263	·7614016	·7614768	·7615520	·7616272	·7617024	·7617775	·7618527	752
578	·7619278	·7620030	·7620781	·7621532	·7622283	·7623034	·7623784	·7624535	·7625285	·7626035	751
579	·7626786	·7627536	·7628286	·7629035	·7629785	·7630534	·7631284	·7632033	·7632782	·7633531	749
580	·7634280	·7635029	·7635777	·7636526	·7637274	·7638022	·7638770	·7639518	·7640266	·7641014	748
581	·7641761	·7642509	·7643256	·7644003	·7644750	·7645497	·7646244	·7646991	·7647737	·7648484	747
582	·7649230	·7649976	·7650722	·7651468	·7652214	·7652959	·7653705	·7654450	·7655195	·7655941	746
583	·7656686	·7657430	·7658175	·7658920	·7659664	·7660409	·7661153	·7661897	·7662641	·7663385	744
584	·7664128	·7664872	·7665616	·7666359	·7667102	·7667845	·7668588	·7669331	·7670074	·7670816	743
585	·7671559	·7672301	·7673043	·7673785	·7674527	·7675269	·7676011	·7676752	·7677494	·7678235	742
586	·7678976	·7679717	·7680458	·7681199	·7681940	·7682680	·7683421	·7684161	·7684901	·7685641	740
587	·7686381	·7687121	·7687860	·7688600	·7689339	·7690079	·7690818	·7691557	·7692296	·7693035	739
588	·7693773	·7694512	·7695250	·7695988	·7696727	·7697465	·7698203	·7698940	·7699678	·7700416	738
589	·7701153	·7701890	·7702627	·7703364	·7704101	·7704838	·7705575	·7706311	·7707048	·7707784	737
590	·7708520	·7709256	·7709992	·7710728	·7711463	·7712199	·7712934	·7713670	·7714405	·7715140	735
591	·7715875	·7716610	·7717344	·7718079	·7718813	·7719547	·7720282	·7721016	·7721750	·7722483	734
592	·7723217	·7723951	·7724684	·7725417	·7726150	·7726884	·7727616	·7728349	·7729082	·7729815	733
593	·7730547	·7731279	·7732011	·7732743	·7733475	·7734207	·7734939	·7735670	·7736402	·7737133	732
594	·7737864	·7738596	·7739326	·7740057	·7740788	·7741519	·7742249	·7742979	·7743710	·7744440	731
595	·7745170	·7745900	·7746629	·7747359	·7748088	·7748818	·7749547	·7750276	·7751005	·7751734	729
596	·7752463	·7753191	·7753920	·7754648	·7755376	·7756104	·7756832	·7757560	·7758288	·7759016	728
597	·7759743	·7760471	·7761198	·7761925	·7762652	·7763379	·7764106	·7764833	·7765559	·7766286	727
598	·7767012	·7767738	·7768464	·7769190	·7769916	·7770642	·7771367	·7772093	·7772818	·7773543	726
599	·7774268	·7774993	·7775718	·7776443	·7777167	·7777892	·7778616	·7779340	·7780065	·7780789	725
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
00	·7781513	·7782236	·7782960	·7783683	·7784407	·7785130	·7785853	·7786576	·7787299	·7788022	723
01	·7788745	·7789467	·7790190	·7790912	·7791634	·7792356	·7793078	·7793800	·7794522	·7795243	722
02	·7795965	·7796686	·7797408	·7798129	·7798850	·7799571	·7800291	·7801012	·7801732	·7802453	721
03	·7803173	·7803893	·7804613	·7805333	·7806053	·7806773	·7807492	·7808212	·7808931	·7809650	720
04	·7810369	·7811088	·7811807	·7812526	·7813245	·7813963	·7814681	·7815400	·7816118	·7816836	718
05	·7817554	·7818272	·7818989	·7819707	·7820424	·7821141	·7821859	·7822576	·7823293	·7824010	717
06	·7824726	·7825443	·7826159	·7826876	·7827592	·7828308	·7829024	·7829740	·7830456	·7831171	716
07	·7831887	·7832602	·7833318	·7834033	·7834748	·7835463	·7836178	·7836892	·7837607	·7838321	715
08	·7839036	·7839750	·7840464	·7841178	·7841892	·7842606	·7843319	·7844033	·7844746	·7845460	713
09	·7846173	·7846886	·7847599	·7848312	·7849024	·7849737	·7850450	·7851162	·7851874	·7852586	712
10	·7853298	·7854010	·7854722	·7855434	·7856145	·7856857	·7857568	·7858279	·7858990	·7859701	711
11	·7860412	·7861123	·7861833	·7862544	·7863254	·7863965	·7864675	·7865385	·7866095	·7866805	711
12	·7867514	·7868224	·7868933	·7869648	·7870352	·7871061	·7871770	·7872479	·7873188	·7873896	710
13	·7874605	·7875313	·7876021	·7876730	·7877438	·7878146	·7878854	·7879561	·7880269	·7880976	708
14	·7881684	·7882391	·7883098	·7883805	·7884512	·7885219	·7885926	·7886632	·7887339	·7888045	707
15	·7888751	·7889457	·7890163	·7890869	·7891575	·7892281	·7892986	·7893692	·7894397	·7895102	706
16	·7895807	·7896512	·7897217	·7897922	·7898626	·7899331	·7900035	·7900739	·7901444	·7902148	705
17	·7902852	·7903555	·7904259	·7904963	·7905666	·7906370	·7907073	·7907776	·7908479	·7909182	703
18	·7909885	·7910587	·7911290	·7911992	·7912695	·7913397	·7914099	·7914801	·7915503	·7916205	702
19	·7916906	·7917608	·7918309	·7919011	·7919712	·7920413	·7921114	·7921815	·7922516	·7923216	701
20	·7923917	·7924617	·7925318	·7926018	·7926718	·7927418	·7928118	·7928817	·7929517	·7930217	700
21	·7930916	·7931615	·7932314	·7933014	·7933712	·7934411	·7935110	·7935809	·7936507	·7937206	699
22	·7937904	·7938602	·7939300	·7939998	·7940696	·7941394	·7942091	·7942789	·7943486	·7944183	698
23	·7944880	·7945578	·7946274	·7946971	·7947668	·7948365	·7949061	·7949757	·7950454	·7951150	697
24	·7951846	·7952542	·7953238	·7953933	·7954629	·7955324	·7956020	·7956715	·7957410	·7958105	696
o.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
625	·7958800	·7959495	·7960190	·7960884	·7961579	·7962273	·7962967	·7963662	·7964356	·7965050	694
626	·7965743	·7966437	·7967131	·7967824	·7968517	·7969211	·7969904	·7970597	·7971290	·7971983	693
627	·7972675	·7973368	·7974060	·7974753	·7975445	·7976137	·7976829	·7977521	·7978213	·7978905	692
628	·7979596	·7980288	·7980979	·7981671	·7982362	·7983053	·7983744	·7984435	·7985125	·7985816	691
629	·7986506	·7987197	·7987887	·7988577	·7989267	·7989957	·7990647	·7991337	·7992027	·7992716	690
630	·7993405	·7994095	·7994784	·7995473	·7996162	·7996851	·7997540	·7998228	·7998917	·7999605	689
631	·8000294	·8000982	·8001670	·8002358	·8003046	·8003734	·8004421	·8005109	·8005796	·8006484	688
632	·8007171	·8007858	·8008545	·8009232	·8009919	·8010605	·8011292	·8011978	·8012665	·8013351	687
633	·8014037	·8014723	·8015409	·8016095	·8016781	·8017466	·8018152	·8018837	·8019522	·8020208	686
634	·8020893	·8021578	·8022262	·8022947	·8023632	·8024316	·8025001	·8025685	·8026369	·8027053	685
635	·8027737	·8028421	·8029105	·8029789	·8030472	·8031156	·8031839	·8032522	·8033205	·8033888	684
636	·8034571	·8035254	·8035937	·8036619	·8037302	·8037984	·8038666	·8039348	·8040031	·8040712	682
637	·8041394	·8042076	·8042758	·8043439	·8044121	·8044802	·8045483	·8046164	·8046845	·8047526	681
638	·8048207	·8048887	·8049568	·8050248	·8050929	·8051609	·8052289	·8052969	·8053649	·8054329	680
639	·8055009	·8055688	·8056368	·8057047	·8057726	·8058405	·8059085	·8059764	·8060442	·8061121	679
640	·8061800	·8062478	·8063157	·8063835	·8064513	·8065191	·8065869	·8066547	·8067225	·8067903	678
641	·8068580	·8069258	·8069935	·8070612	·8071290	·8071967	·8072644	·8073320	·8073997	·8074674	677
642	·8075350	·8076027	·8076073	·8077379	·8078055	·8078731	·8079407	·8080083	·8080759	·8081434	676
643	·8082110	·8082785	·8083460	·8084136	·8084811	·8085486	·8086160	·8086835	·8087510	·8088184	675
644	·8088859	·8089533	·8090207	·8090881	·8091555	·8092229	·8092903	·8093577	·8094250	·8094924	674
645	·8095597	·8096270	·8096944	·8097617	·8098290	·8098962	·8099635	·8100308	·8100980	·8101653	673
646	·8102325	·8102997	·8103670	·8104342	·8105013	·8105685	·8106357	·8107029	·8107700	·8108372	672
647	·8109043	·8109714	·8110385	·8111056	·8111727	·8112398	·8113068	·8113739	·8114409	·8115080	671
648	·8115750	·8116420	·8117090	·8117760	·8118430	·8119100	·8119769	·8120439	·8121108	·8121778	670
649	·8122447	·8123116	·8123785	·8124454	·8125123	·8125792	·8126460	·8127129	·8127797	·8128465	669
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
650	·8129134	·8129802	·8130470	·8131138	·8131805	·8132473	·8133141	·8133808	·8134475	·8135143	668
651	·8135810	·8136477	·8137144	·8137811	·8138478	·8139144	·8139811	·8140477	·8141144	·8141810	667
652	·8142476	·8143142	·8143808	·8144474	·8145140	·8145805	·8146471	·8147136	·8147801	·8148467	666
653	·8149132	·8149797	·8150462	·8151127	·8151791	·8152456	·8153120	·8153785	·8154449	·8155113	665
654	·8155777	·8156441	·8157105	·8157769	·8158433	·8159097	·8159760	·8160423	·8161087	·8161750	664
655	·8162413	·8163076	·8163739	·8164402	·8165064	·8165727	·8166389	·8167052	·8167714	·8168376	663
656	·8169038	·8169700	·8170362	·8171024	·8171686	·8172347	·8173009	·8173670	·8174331	·8174993	662
657	·8175654	·8176315	·8176976	·8177636	·8178297	·8178958	·8179618	·8180278	·8180939	·8181599	661
658	·8182259	·8182919	·8183579	·8184239	·8184898	·8185558	·8186217	·8186877	·8187536	·8188195	660
659	·8188854	·8189513	·8190172	·8190831	·8191489	·8192148	·8192806	·8193465	·8194123	·8194781	658
660	·8195439	·8196097	·8196755	·8197413	·8198071	·8198728	·8199386	·8200043	·8200700	·8201358	657
661	·8202015	·8202672	·8203328	·8203985	·8204642	·8205298	·8205955	·8206611	·8207268	·8207924	656
662	·8208580	·8209236	·8209892	·8210548	·8211203	·8211859	·8212514	·8213170	·8213825	·8214480	655
663	·8215135	·8215790	·8216445	·8217100	·8217755	·8218409	·8219064	·8219718	·8220372	·8221027	654
664	·8221681	·8222335	·8222989	·8223643	·8224296	·8224950	·8225603	·8226257	·8226910	·8227563	653
665	·8228216	·8228869	·8229522	·8230175	·8230828	·8231481	·8232133	·8232786	·8233438	·8234090	652
666	·8234742	·8235394	·8236046	·8236698	·8237350	·8238002	·8238653	·8239305	·8239956	·8240607	651
667	·8241258	·8241909	·8242560	·8243211	·8243862	·8244513	·8245163	·8245814	·8246464	·8247114	651
668	·8247765	·8248415	·8249065	·8249715	·8250364	·8251014	·8251664	·8252313	·8252963	·8253612	650
669	·8254261	·8254910	·8255559	·8256208	·8256857	·8257506	·8258154	·8258803	·8259451	·8260100	649
670	·8260748	·8261396	·8262044	·8262692	·8263340	·8263988	·8264635	·8265283	·8265931	·8266578	648
671	·8267225	·8267872	·8268519	·8269166	·8269813	·8270460	·8271107	·8271753	·8272400	·8273046	647
672	·8273693	·8274339	·8274985	·8275631	·8276277	·8276923	·8277569	·8278214	·8278860	·8279505	646
673	·8280151	·8280796	·8281441	·8282086	·8282731	·8283376	·8284021	·8284665	·8285310	·8285955	645
674	·8286599	·8287243	·8287887	·8288532	·8289176	·8289820	·8290463	·8291107	·8291751	·8292394	644
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
675	·8293038	·8293681	·8294324	·8294967	·8295611	·8296254	·8296896	·8297539	·8298182	·8298824	643
676	·8299467	·8300109	·8300752	·8301394	·8302036	·8302678	·8303320	·8303962	·8304604	·8305245	642
677	·8305887	·8306528	·8307169	·8307811	·8308452	·8309093	·8309734	·8310375	·8311016	·8311656	641
678	·8312297	·8312937	·8313578	·8314218	·8314858	·8315499	·8316139	·8316778	·8317418	·8318058	640
679	·8318698	·8319337	·8319977	·8320616	·8321255	·8321895	·8322534	·8323173	·8323812	·8324450	639
680	·8325089	·8325728	·8326366	·8327005	·8327643	·8328281	·8328919	·8329558	·8330195	·8330833	638
681	·8331471	·8332109	·8332746	·8333384	·8334021	·8334659	·8335296	·8335933	·8336570	·8337207	637
682	·8337844	·8338480	·8339117	·8339754	·8340390	·8341027	·8341663	·8342299	·8342935	·8343571	636
683	·8344207	·8344843	·8345479	·8346114	·8346750	·8347385	·8348021	·8348656	·8349291	·8349926	635
684	·8350561	·8351196	·8351831	·8352465	·8353100	·8353735	·8354369	·8355003	·8355638	·8356272	634
685	·8356906	·8357540	·8358174	·8358807	·8359441	·8360075	·8360708	·8361341	·8361975	·8362608	633
686	·8363241	·8363874	·8364507	·8365140	·8365773	·8366405	·8367038	·8367670	·8368303	·8368935	632
687	·8369567	·8370199	·8370832	·8371463	·8372095	·8372727	·8373359	·8373990	·8374622	·8375253	632
688	·8375884	·8376516	·8377147	·8377778	·8378409	·8379039	·8379670	·8380301	·8380931	·8381562	631
689	·8382192	·8382822	·8383453	·8384083	·8384713	·8385343	·8385973	·8386602	·8327232	·8387861	630
690	·8388491	·8389120	·8389750	·8390379	·8391008	·8391637	·8392266	·8392895	·8393523	·8394152	629
691	·8394780	·8395409	·8396037	·8396666	·8397294	·8397922	·8398550	·8399178	·8399806	·8400433	628
692	·8401061	·8401688	·8402316	·8402943	·8403571	·8404198	·8404825	·8405452	·8406079	·8406706	627
693	·8407332	·8407959	·8408586	·8409212	·8409838	·8410465	·8411091	·8411717	·8412343	·8412969	626
694	·8413595	·8414220	·8414846	·8415472	·8416097	·8416723	·8417348	·8417973	·8418598	·8419223	625
695	·8419848	·8420473	·8421098	·8421722	·8422347	·8422971	·8423596	·8424220	·8424844	·8425468	624
696	·8426092	·8426716	·8427340	·8427964	·8428588	·8429211	·8429835	·8430458	·8431081	·8431705	624
697	·8432328	·8432951	·8433574	·8434197	·8434819	·8435442	·8436065	·8436687	·8437310	·8437932	623
698	·8438554	·8439176	·8439798	·8440420	·8441042	·8441664	·8442286	·8442907	·8443529	·8444150	622
699	·8444772	·8445393	·8446014	·8446635	·8447256	·8447877	·8448498	·8449119	·8449739	·8450360	621
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
700	·8450980	·8451601	·8452221	·8452841	·8453461	·8454081	·8454701	·8455321	·8455941	·8456561	620
701	·8457180	·8457800	·8458419	·8459038	·8459658	·8460277	·8460896	·8461515	·8462134	·8462752	619
702	·8463371	·8463990	·8464608	·8465227	·8465845	·8466463	·8467081	·8467700	·8468318	·8468935	618
703	·8469553	·8470171	·8470789	·8471406	·8472024	·8472641	·8473258	·8473876	·8474493	·8475110	617
704	·8475727	·8476343	·8476960	·8477577	·8478193	·8478810	·8479426	·8480043	·8480659	·8481275	616
705	·8481891	·8482507	·8483123	·8483739	·8484355	·8484970	·8485586	·8486201	·8486817	·8487432	615
706	·8488047	·8488662	·8489277	·8489892	·8490507	·8491122	·8491736	·8492351	·8492965	·8493580	615
707	·8494194	·8494808	·8495423	·8496037	·8496651	·8497264	·8497878	·8498492	·8499106	·8499719	614
708	·8500333	·8500946	·8501559	·8502172	·8502786	·8503399	·8504011	·8504624	·8505237	·8505850	613
709	·8506462	·8507075	·8507687	·8508300	·8508912	·8509524	·8510136	·8510748	·8511360	·8511972	612
710	·8512583	·8513195	·8513807	·8514418	·8515030	·8515641	·8516252	·8516863	·8517474	·8518085	611
711	·8518696	·8519307	·8519917	·8520528	·8521139	·8521749	·8522359	·8522970	·8523580	·8524190	610
712	·8524800	·8525410	·8526020	·8526629	·8527239	·8527849	·8528458	·8529068	·8529677	·8530286	609
713	·8530895	·8531504	·8532113	·8532722	·8533331	·8533940	·8534548	·8535157	·8535765	·8536374	608
714	·8536982	·8537590	·8538198	·8538807	·8539414	·8540022	·8540630	·8541238	·8541845	·8542453	607
715	·8543060	·8543668	·8544275	·8544882	·8545489	·8546096	·8546703	·8547310	·8547917	·8548524	607
716	·8549130	·8549737	·8550343	·8550950	·8551556	·8552162	·8552768	·8553374	·8553980	·8554586	606
717	·8555192	·8555797	·8556403	·8557008	·8557614	·8558219	·8558824	·8559429	·8560035	·8560640	605
718	·8561244	·8561849	·8562454	·8563059	·8563663	·8564268	·8564872	·8565476	·8566081	·8566685	604
719	·8567289	·8567893	·8568497	·8569101	·8569704	·8570308	·8570912	·8571515	·8572118	·8572722	603
720	·8573325	·8573928	·8574531	·8575134	·8575737	·8576340	·8576943	·8577545	·8578148	·8578750	603
721	·8579353	·8579955	·8580557	·8581159	·8581761	·8582363	·8582965	·8583567	·8584169	·8584770	602
722	·8585372	·8585973	·8586575	·8587176	·8587777	·8588379	·8588980	·8589581	·8590181	·8590782	601
723	·8591383	·8591984	·8592584	·8593185	·8593785	·8594385	·8594986	·8595586	·8596186	·8596786	600
724	·8597386	·8597985	·8598585	·8599185	·8599784	·8600384	·8600983	·8601583	·8602182	·8602781	600
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
725	·8603380	·8603979	·8604578	·8605177	·8605776	·8606374	·8606973	·8607571	·8608170	·8608768	599
726	·8609366	·8609964	·8610562	·8611160	·8611758	·8612356	·8612954	·8613552	·8614149	·8614747	598
727	·8615344	·8615941	·8616539	·8617136	·8617733	·8618330	·8618927	·8619524	·8620121	·8620717	597
728	·8621314	·8621910	·8622507	·8623103	·8623699	·8624296	·8624892	·8625488	·8626084	·8626680	596
729	·8627275	·8627871	·8628467	·8629062	·8629658	·8630253	·8630848	·8631443	·8632039	·8632634	595
730	·8633229	·8633823	·8634418	·8635013	·8635608	·8636202	·8636797	·8637391	·8637985	·8638580	594
731	·8639174	·8639768	·8640362	·8640956	·8641550	·8642143	·8642737	·8643331	·8643924	·8644517	593
732	·8645111	·8645704	·8646297	·8646890	·8647483	·8648076	·8648669	·8649262	·8649855	·8650447	592
733	·8651040	·8651632	·8652225	·8652817	·8653409	·8654001	·8654593	·8655185	·8655777	·8656369	592
734	·8656961	·8657552	·8658144	·8658735	·8659327	·8659918	·8660509	·8661100	·8661691	·8662282	591
735	·8662873	·8663464	·8664055	·8664646	·8665236	·8665827	·8666417	·8667008	·8667598	·8668188	591
736	·8668778	·8669368	·8669958	·8670548	·8671138	·8671728	·8672317	·8672907	·8673496	·8674086	590
737	·8674675	·8675264	·8675853	·8676442	·8677031	·8677620	·8678209	·8678798	·8679387	·8679975	589
738	·8680564	·8681152	·8681740	·8682329	·8682917	·8683505	·8684093	·8684681	·8685269	·8685857	588
739	·8686444	·8687032	·8687620	·8688207	·8688794	·8689382	·8689969	·8690556	·8691143	·8691730	588
740	·8692317	·8692904	·8693491	·8694077	·8694664	·8695251	·8695837	·8696423	·8697010	·8697596	587
741	·8698182	·8698768	·8699354	·8699940	·8700526	·8701112	·8701697	·8702283	·8702868	·8703454	586
742	·8704039	·8704624	·8705210	·8705795	·8706380	·8706965	·8707549	·8708134	·8708719	·8709304	585
743	·8709888	·8710473	·8711057	·8711641	·8712226	·8712810	·8713394	·8713978	·8714562	·8715146	584
744	·8715729	·8716313	·8716897	·8717480	·8718064	·8718647	·8719230	·8719814	·8720397	·8720980	583
745	·8721563	·8722146	·8722728	·8723311	·8723894	·8724476	·8725059	·8725641	·8726224	·8726806	582
746	·8727388	·8727970	·8728552	·8729134	·8729716	·8730298	·8730880	·8731462	·8732043	·8732625	582
747	·8733206	·8733787	·8734369	·8734950	·8735531	·8736112	·8736693	·8737274	·8737855	·8738435	581
748	·8739016	·8739597	·8740177	·8740757	·8741338	·8741918	·8742498	·8743078	·8743658	·8744238	580
749	·8744818	·8745398	·8745978	·8746557	·8747137	·8747716	·8748296	·8748875	·8749454	·8750034	579
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
750	·8750613	·8751192	·8751771	·8752349	·8752928	·8753507	·8754086	·8754664	·8755243	·8755821	579
751	·8756399	·8756978	·8757556	·8758134	·8758712	·8759290	·8759868	·8760446	·8761023	·8761601	578
752	·8762178	·8762756	·8763333	·8763911	·8764488	·8765065	·8765642	·8766219	·8766796	·8767373	577
753	·8767950	·8768526	·8769103	·8769680	·8770256	·8770833	·8771409	·8771985	·8772561	·8773137	577
754	·8773713	·8774289	·8774865	·8775441	·8776017	·8776592	·8777168	·8777743	·8778319	·8778894	576
755	·8779470	·8780045	·8780620	·8781195	·8781170	·8782345	·8782919	·8783494	·8784069	·8784643	575
756	·8785218	·8785792	·8786367	·8786941	·8787515	·8788089	·8788663	·8789237	·8789811	·8790385	574
757	·8790959	·8791532	·8792106	·8792680	·8793253	·8793826	·8794400	·8794973	·8795546	·8796119	574
758	·8796692	·8797265	·8797838	·8798411	·8798983	·8799556	·8800128	·8800701	·8801273	·8801846	573
759	·8802418	·8802990	·8803562	·8804134	·8804706	·8805278	·8805850	·8806421	·8806993	·8807564	572
760	·8808136	·8808707	·8809279	·8809850	·8810421	·8810992	·8811563	·8812134	·8812705	·8813276	571
761	·8813847	·8814417	·8814988	·8815558	·8816129	·8816699	·8817269	·8817840	·8818410	·8818980	570
762	·8819550	·8820120	·8820689	·8821259	·8821829	·8822398	·8822968	·8823537	·8824107	·8824676	569
763	·8825245	·8825815	·8826384	·8826953	·8827522	·8828090	·8828659	·8829228	·8829797	·8830365	569
764	·8830934	·8831502	·8832070	·8832639	·8833207	·8833775	·8834343	·8834911	·8835479	·8836047	568
765	·8836614	·8837182	·8837750	·8838317	·8838885	·8839452	·8840019	·8840586	·8841154	·8841721	567
766	·8842288	·8842855	·8843421	·8843988	·8844555	·8845122	·8845688	·8846255	·8846821	·8847387	567
767	·8847954	·8848520	·8849086	·8849652	·8850218	·8850784	·8851350	·8851915	·8852481	·8853047	566
768	·8853612	·8854178	·8854743	·8855308	·8855874	·8856439	·8857004	·8857569	·8858134	·8858699	565
769	·8859263	·8859828	·8860393	·8860957	·8861522	·8862086	·8862651	·8863215	·8863779	·8864343	564
770	·8864907	·8865471	·8866035	·8866599	·8867163	·8867726	·8868290	·8868854	·8869417	·8869980	564
771	·8870544	·8871107	·8871670	·8872233	·8872796	·8873359	·8873922	·8874485	·8875048	·8875610	563
772	·8876173	·8876736	·8877298	·8877860	·8878423	·8878985	·8879547	·8880109	·8880671	·8881233	562
773	·8881795	·8882357	·8882918	·8883480	·8884042	·8884603	·8885165	·8885726	·8886287	·8886848	562
774	·8887410	·8887971	·8888532	·8889093	·8889653	·8890214	·8890775	·8891336	·8891896	·8892457	561
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
775	·8893017	·8893577	·8894138	·8894698	·8895258	·8895818	·8896378	·8896938	·8897498	·8898058	560
776	·8898617	·8899177	·8899736	·8900296	·8900855	·8901415	·8901974	·8902533	·8903092	·8903651	559
777	·8904210	·8904769	·8905328	·8905887	·8906445	·8907004	·8907563	·8908121	·8908679	·8909238	558
778	·8909796	·8910354	·8910912	·8911470	·8912028	·8912586	·8913144	·8913702	·8914259	·8914817	558
779	·8915375	·8915932	·8916489	·8917047	·8917604	·8918161	·8918718	·8919275	·8919832	·8920389	557
780	·8920946	·8921503	·8922059	·8922616	·8923173	·8923729	·8924285	·8924842	·8925398	·8925954	557
781	·8926510	·8927066	·8927622	·8928178	·8928734	·8929290	·8929846	·8930401	·8930957	·8931512	556
782	·8932068	·8932623	·8933178	·8933733	·8934288	·8934843	·8935398	·8935953	·8936508	·8937063	555
783	·8937618	·8938172	·8938727	·8939281	·8939836	·8940390	·8940944	·8941498	·8942053	·8942607	555
784	·8943161	·8943715	·8944268	·8944822	·8945376	·8945929	·8946483	·8947037	·8947590	·8948143	554
785	·8948697	·8949250	·8949803	·8950356	·8950909	·8951462	·8952015	·8952568	·8953120	·8953673	553
786	·8954225	·8954778	·8955330	·8955883	·8956435	·8956987	·8957539	·8958092	·8958644	·8959195	552
787	·8959747	·8960299	·8960851	·8961403	·8961954	·8962506	·8963057	·8963608	·8964160	·8964711	551
788	·8965262	·8965813	·8966364	·8966915	·8967466	·8968017	·8968568	·8969118	·8969669	·8970220	551
789	·8970770	·8971320	·8971871	·8972421	·8972971	·8973521	·8974071	·8974621	·8975171	·8975721	550
790	·8976271	·8976821	·8977370	·8977920	·8978469	·8979019	·8979568	·8980117	·8980667	·8981216	549
791	·8981765	·8982314	·8982863	·8983412	·8983960	·8984509	·8985058	·8985606	·8986155	·8986703	549
792	·8987252	·8987800	·8988348	·8988897	·8989445	·8989993	·8990541	·8991089	·8991636	·8992184	548
793	·8992732	·8993279	·8993827	·8994375	·8994922	·8995469	·8996017	·8996564	·8997111	·8997658	547
794	·8998205	·8998752	·8999299	·8999846	·9000392	·9000939	·9001486	·9002032	·9002579	·9003125	547
795	·9003671	·9004218	·9004764	·9005310	·9005856	·9006402	·9006948	·9007494	·9008039	·9008585	546
796	·9009131	·9009676	·9010222	·9010767	·9011313	·9011858	·9012403	·9012948	·9013493	·9014038	545
797	·9014583	·9015128	·9015673	·9016218	·9016762	·9017307	·9017851	·9018396	·9018940	·9019485	545
798	·9020029	·9020573	·9021117	·9021661	·9022205	·9022749	·9023293	·9023837	·9024381	·9024924	544
799	·9025468	·9026011	·9026555	·9027098	·9027641	·9028185	·9028728	·9029271	·9029814	·9030357	543
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
800	·9030900	·9031443	·9031985	·9032528	·9033071	·9033613	·9034156	·9034698	·9035241	·9035783	542
801	·9036325	·9036867	·9037409	·9037951	·9038493	·9039035	·9039577	·9040119	·9040661	·9041202	542
802	·9041744	·9042285	·9042827	·9043368	·9043909	·9044450	·9044992	·9045533	·9046074	·9046615	541
803	·9047155	·9047696	·9048237	·9048778	·9049318	·9049859	·9050399	·9050940	·9051480	·9052020	540
804	·9052560	·9053101	·9053641	·9054181	·9054721	·9055260	·9055800	·9056340	·9056880	·9057419	539
805	·9057959	·9058498	·9059038	·9059577	·9060116	·9060655	·9061195	·9061734	·9062273	·9062812	539
806	·9063350	·9063889	·9064428	·9064967	·9065505	·9066044	·9066582	·9067121	·9067659	·9068197	538
807	·9068735	·9069273	·9069812	·9070350	·9070887	·9071425	·9071963	·9072501	·9073038	·9073576	537
808	·9074114	·9074651	·9075188	·9075726	·9076263	·9076800	·9077337	·9077874	·9078411	·9078948	537
809	·9079485	·9080022	·9080559	·9081095	·9081632	·9082169	·9082705	·9083241	·9083778	·9084314	536
810	·9084850	·9085386	·9085922	·9086458	·9086994	·9087530	·9088066	·9088602	·9089137	·9089673	536
811	·9090209	·9090744	·9091279	·9091815	·9092350	·9092885	·9093420	·9093955	·9094490	·9095025	535
812	·9095560	·9096095	·9096630	·9097165	·9097699	·9098234	·9098768	·9099303	·9099837	·9100371	534
813	·9100905	·9101440	·9101974	·9102508	·9103042	·9103576	·9104109	·9104643	·9105177	·9105710	534
814	·9106244	·9106778	·9107311	·9107844	·9108378	·9108911	·9109444	·9109977	·9110510	·9111043	533
815	·9111576	·9112109	·9112642	·9113174	·9113707	·9114240	·9114772	·9115305	·9115837	·9116369	533
816	·9116902	·9117434	·9117966	·9118498	·9110030	·9119562	·9120094	·9120626	·9121157	·9121689	532
817	·9122221	·9122752	·9123284	·9123815	·9124346	·9124878	·9125409	·9125940	·9126471	·9127002	531
818	·9127533	·9128064	·9128595	·9129126	·9129656	·9130187	·9130717	·9131248	·9131778	·9132309	531
819	·9132839	·9133369	·9133899	·9134430	·9134960	·9135490	·9136019	·9136549	·9137079	·9137609	530
820	·9138139	·9138668	·9139198	·9139727	·9140257	·9140786	·9141315	·9141844	·9142373	·9142903	530
821	·9143432	·9143961	·9144489	·9145018	·9145547	·9146076	·9146604	·9147133	·9147661	·9148190	529
822	·9148718	·9149246	·9149775	·9150303	·9150831	·9151359	·9151887	·9152415	·9152943	·9153471	528
823	·9153998	·9154526	·9155054	·9155581	·9156109	·9156636	·9157163	·9157691	·9158218	·9158745	527
824	·9159272	·9159799	·9160326	·9160853	·9161380	·9161907	·9162433	·9162960	·9163487	·9164013	526
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
825	·9164539	·9165066	·9165592	·9166118	·9166645	·9167171	·9167697	·9168223	·9168749	·9169275	526
826	·9169800	·9170326	·9170852	·9171378	·9171903	·9172429	·9172954	·9173479	·9174005	·9174530	526
827	·9175055	·9175580	·9176105	·9176630	·9177155	·9177680	·9178205	·9178730	·9179254	·9179779	525
828	·9180303	·9180828	·9181352	·9181877	·9182401	·9182925	·9183449	·9183973	·9184497	·9185021	524
829	·9185545	·9186069	·9186593	·9187117	·9187640	·9188164	·9188687	·9189211	·9189734	·9190258	523
830	·9190781	·9191304	·9191827	·9192350	·9192873	·9193396	·9193919	·9194442	·9194965	·9195488	523
831	·9196010	·9196533	·9197055	·9197578	·9198100	·9198623	·9199145	·9199667	·9200189	·9200711	522
832	·9201233	·9201755	·9202277	·9202799	·9203321	·9203842	·9204364	·9204886	·9205407	·9205929	522
833	·9206450	·9206971	·9207493	·9208014	·9208535	·9209056	·9209577	·9210098	·9210619	·9211140	521
834	·9211661	·9212181	·9212702	·9213222	·9213743	·9214263	·9214784	·9215304	·9215824	·9216345	521
835	·9216865	·9217385	·9217905	·9218425	·9218945	·9219465	·9219984	·9220504	·9221024	·9221543	520
836	·9222063	·9222582	·9223102	·9223621	·9224140	·9224659	·9225179	·9225698	·9226217	·9226736	519
837	·9227255	·9227773	·9228292	·9228811	·9229330	·9229848	·9230367	·9230885	·9231404	·9231922	519
838	·9232440	·9232958	·9233477	·9233995	·9234513	·9235031	·9235549	·9236066	·9236584	·9237102	518
839	·9237620	·9238137	·9238655	·9239172	·9239690	·9240207	·9240724	·9241242	·9241759	·9242276	517
840	·9242793	·9243310	·9243827	·9244344	·9244860	·9245377	·9245894	·9246410	·9246927	·9247444	517
841	·9247960	·9248476	·9248993	·9249509	·9250025	·9250541	·9251057	·9251573	·9252089	·9252605	516
842	·9253121	·9253637	·9254152	·9254668	·9255184	·9255699	·9256215	·9256730	·9257245	·9257761	515
843	·9258276	·9258791	·9259306	·9259821	·9260336	·9260851	·9261366	·9261880	·9262395	·9262910	515
844	·9263424	·9263939	·9264453	·9264968	·9265482	·9265997	·9266511	·9267025	·9267539	·9268053	514
845	·9268567	·9269081	·9269595	·9270109	·9270622	·9271136	·9271650	·9272163	·9272677	·9273190	514
846	·9273704	·9274217	·9274730	·9275243	·9275757	·9276270	·9276783	·9277296	·9277808	·9278321	513
847	·9278834	·9279347	·9279859	·9280372	·9280885	·9281397	·9281909	·9282422	·9282934	·9283446	512
848	·9283959	·9284471	·9284983	·9285495	·9286007	·9286518	·9287030	·9287542	·9288054	·9288565	512
849	·9289077	·9289588	·9290100	·9290611	·9291123	·9291634	·9292145	·9292656	·9293167	·9293678	511
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
850	·9294189	·9294700	·9295211	·9295722	·9296233	·9296743	·9297254	·9297764	·9298275	·9298785	511
851	·9299296	·9299806	·9300316	·9300826	·9301336	·9301847	·9302357	·9302866	·9303376	·9303886	511
852	·9304396	·9304906	·9305415	·9305925	·9306434	·9306944	·9307453	·9307963	·9308472	·9308981	510
853	·9309490	·9309999	·9310508	·9311017	·9311526	·9312035	·9312544	·9313053	·9313562	·9314070	509
854	·9314579	·9315087	·9315596	·9316104	·9316612	·9317121	·9317629	·9318137	·9318645	·9319153	509
855	·9319661	·9320169	·9320677	·9321185	·9321692	·9322200	·9322708	·9323215	·9323723	·9324230	508
856	·9324738	·9325245	·9325752	·9326259	·9326767	·9327274	·9327781	·9328288	·9328795	·9329301	507
857	·9329808	·9330315	·9330822	·9331328	·9331835	·9332341	·9332848	·9333354	·9333860	·9334367	507
858	·9334873	·9335379	·9335885	·9336391	·9336897	·9337403	·9337909	·9338415	·9338920	·9339426	506
859	·9339932	·9340437	·9340943	·9341448	·9341953	·9342459	·9342964	·9343469	·9343974	·9344479	505
860	·9344985	·9345489	·9345994	·9346499	·9347004	·9347509	·9348013	·9348518	·9349023	·9349527	505
861	·9350032	·9350536	·9351040	·9351544	·9352049	·9352553	·9353057	·9353561	·9354065	·9354569	504
862	·9355073	·9355576	·9356080	·9356584	·9357087	·9357591	·9358095	·9358598	·9359101	·9359605	503
863	·9360108	·9360611	·9361114	·9361617	·9362120	·9362623	·9363126	·9363629	·9364132	·9364635	503
864	·9365137	·9365640	·9366143	·9366645	·9367148	·9367650	·9368152	·9368655	·9369157	·9369659	502
865	·9370161	·9370663	·9371165	·9371667	·9372169	·9372671	·9373172	·9373674	·9374176	·9374677	502
866	·9375179	·9375680	·9376182	·9376683	·9377184	·9377686	·9378187	·9378688	·9379189	·9379690	501
867	·9380191	·9380692	·9381193	·9381693	·9382194	·9382695	·9383195	·9383696	·9384196	·9384697	501
868	·9385197	·9385698	·9386198	·9386698	·9387198	·9387698	·9388198	·9388698	·9389198	·9389698	500
869	·9390198	·9390697	·9391197	·9391697	·9392196	·9392696	·9393195	·9393695	·9394194	·9394693	500
870	·9395193	·9395692	·9396191	·9396690	·9397189	·9397688	·9398187	·9398685	·9399184	·9399683	499
871	·9400182	·9400680	·9401179	·9401677	·9402176	·9402674	·9403172	·9403670	·9404169	·9404667	498
872	·9405165	·9405663	·9406161	·9406659	·9407157	·9407654	·9408152	·9408650	·9409147	·9409645	498
873	·9410142	·9410640	·9411137	·9411635	·9412132	·9412629	·9413126	·9413623	·9414120	·9414617	497
874	·9415114	·9415611	·9416108	·9416605	·9417101	·9417598	·9418095	·9418591	·9419088	·9419584	497
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
875	·9420081	·9420577	·9421073	·9421569	·9422065	·9422562	·9423058	·9423553	·9424049	·9424545	496
876	·9425041	·9425537	·9426032	·9426528	·9427024	·9427519	·9428015	·9428510	·9429005	·9429501	495
877	·9429996	·9430491	·9430986	·9431481	·9431976	·9432471	·9432966	·9433461	·9433956	·9434450	495
878	·9434945	·9435440	·9435934	·9436429	·9436923	·9437418	·9437912	·9438406	·9438900	·9439395	494
879	·9439889	·9440383	·9440877	·9441371	·9441865	·9442358	·9442852	·9443346	·9443840	·9444333	494
880	·9444827	·9445320	·9445814	·9446307	·9446800	·9447294	·9447787	·9448280	·9448773	·9449266	493
881	·9449759	·9450252	·9450745	·9451238	·9451730	·9452223	·9452716	·9453208	·9453701	·9454193	492
882	·9454686	·9455178	·9455671	·9456163	·9456655	·9457147	·9457639	·9458131	·9458623	·9459115	492
883	·9459607	·9460099	·9460591	·9461082	·9461574	·9462066	·9462557	·9463049	·9463540	·9464031	491
884	·9464523	·9465014	·9465505	·9465996	·9466487	·9466978	·9467469	·9467960	·9468451	·9468942	491
885	·9469433	·9469923	·9470414	·9470905	·9471395	·9471886	·9472376	·9472866	·9473357	·9473847	490
886	·9474337	·9474827	·9475317	·9475807	·9476297	·9476787	·9477277	·9477767	·9478257	·9478747	490
887	·9479236	·9479726	·9480215	·9480705	·9481194	·9481684	·9482173	·9482662	·9483151	·9483641	489
888	·9484130	·9484619	·9485108	·9485597	·9486085	·9486574	·9487063	·9487552	·9488040	·9488529	489
889	·9489018	·9489506	·9489995	·9490483	·9490971	·9491460	·9491948	·9492436	·9492924	·9493412	488
890	·9493900	·9494388	·9494876	·9495364	·9495852	·9496339	·9496827	·9497315	·9497802	·9498290	488
891	·9498777	·9499264	·9499752	·9500239	·9500726	·9501213	·9501701	·9502188	·9502675	·9503162	487
892	·9503649	·9504135	·9504622	·9505109	·9505596	·9506082	·9506569	·9507055	·9507542	·9508028	487
893	·9508515	·9509001	·9509487	·9509973	·9510459	·9510946	·9511432	·9511918	·9512404	·9512889	486
894	·9513375	·9513861	·9514347	·9514832	·9515318	·9515803	·9516289	·9516774	·9517260	·9517745	486
895	·9518230	·9518716	·9519201	·9519686	·9520171	·9520656	·9521141	·9521626	·9522111	·9522595	485
896	·9523080	·9523565	·9524049	·9524534	·9525018	·9525503	·9525987	·9526472	·9526956	·9527440	485
897	·9527924	·9528409	·9528893	·9529377	·9529861	·9530345	·9530828	·9531312	·9531796	·9532280	484
898	·9532763	·9533247	·9533731	·9534214	·9534697	·9535181	·9535664	·9536147	·9536631	·9537114	483
899	·9537597	·9538080	·9538563	·9539046	·9539529	·9540012	·9540494	·9540977	·9541460	·9541943	483
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
900	·9542425	·9542908	·9543390	·9543873	·9544355	·9544837	·9545319	·9545802	·9546284	·9546766	482
901	·9547248	·9547730	·9548212	·9548694	·9549176	·9549657	·9550139	·9550621	·9551102	·9551584	482
902	·9552065	·9552547	·9553028	·9553510	·9553991	·9554472	·9554953	·9555434	·9555916	·9556397	481
903	·9556878	·9557358	·9557839	·9558320	·9558801	·9559282	·9559762	·9560243	·9560723	·9561204	481
904	·9561684	·9562165	·9562645	·9563125	·9563606	·9564086	·9564566	·9565046	·9565526	·9566006	480
905	·9566486	·9566966	·9567445	·9567925	·9568405	·9568885	·9569364	·9569844	·9570323	·9570803	480
906	·9571282	·9571761	·9572241	·9572720	·9573199	·9573678	·9574157	·9574636	·9575115	·9575594	479
907	·9576073	·9576552	·9577030	·9577509	·9577988	·9578466	·9578945	·9579423	·9579902	·9580380	479
908	·9580858	·9581337	·9581815	·9582293	·9582771	·9583249	·9583727	·9584205	·9584683	·9585161	478
909	·9585639	·9586117	·9586594	·9587072	·9587549	·9588027	·9588505	·9588982	·9589459	·9589937	478
910	·9590414	·9590891	·9591368	·9591845	·9592322	·9592800	·9593276	·9593753	·9594230	·9594707	477
911	·9595184	·9595660	·9596137	·9596614	·9597090	·9597567	·9598043	·9598520	·9598996	·9599472	477
912	·9599948	·9600425	·9600901	·9601377	·9601853	·9602329	·9602805	·9603281	·9603756	·9604232	476
913	·9604708	·9605183	·9605659	·9606135	·9606610	·9607086	·9607561	·9608036	·9608512	·9608987	476
914	·9609462	·9609937	·9610412	·9610887	·9611362	·9611837	·9612312	·9612787	·9613262	·9613736	475
915	·9614211	·9614686	·9615160	·9615635	·9616109	·9616583	·9617058	·9617532	·9618006	·9618481	474
916	·9618955	·9619429	·9619903	·9620377	·9620851	·9621325	·9621799	·9622272	·9622746	·9623220	474
917	·9623693	·9624167	·9624640	·9625114	·9625587	·9626061	·9626534	·9627007	·9627481	·9627954	473
918	·9628427	·9628900	·9629373	·9629846	·9630319	·9630792	·9631264	·9631737	·9632210	·9632683	473
919	·9633155	·9633628	·9634100	·9634573	·9635045	·9635517	·9635990	·9636462	·9636934	·9637406	472
920	·9637878	·9638350	·9638822	·9639294	·9639766	·9640238	·9640710	·9641181	·9641653	·9642125	472
921	·9642596	·9643068	·9643539	·9644011	·9644482	·9644953	·9645425	·9645896	·9646367	·9646838	471
922	·9647309	·9647780	·9648251	·9648722	·9649193	·9649664	·9650135	·9650605	·9651076	·9651546	471
923	·9652017	·9652488	·9652958	·9653428	·9653899	·9654369	·9654839	·9655309	·9655780	·9656250	470
924	·9656720	·9657190	·9657660	·9658130	·9658599	·9659069	·9659539	·9660009	·9660478	·9660948	470
No.	0	1	2	3	4	5	6	7	8	9	Diff.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
925	·9661417	·9661887	·9662356	·9662826	·9663295	·9663764	·9664233	·9664703	·3665172	·9665641	469
926	·9666110	·9666579	·9667048	·9667517	·9667985	·9668454	·9668923	·9669392	·9669860	·9670329	469
927	·9670797	·9671266	·9671734	·9672203	·9672671	·9673139	·9673607	·9674076	·9674544	·9675012	468
928	·9675480	·9675948	·9676416	·9676884	·9677351	·9677819	·9678287	·9678754	·9679222	·9679690	468
929	·9680157	·9680625	·9681092	·9681559	·9682027	·9682494	·9682961	·9683428	·9683895	·9684362	467
930	·9684829	·9685296	·9685763	·9686230	·9686697	·9687164	·9687630	·9688097	·9688564	·9689030	467
931	·9689497	·9689963	·9690430	·9690896	·9691362	·9691829	·9692295	·9692761	·9693227	·9693693	466
932	·9694159	·9694625	·9695091	·9695557	·9696023	·9696488	·9696954	·9697420	·9697885	·9698351	466
933	·9698816	·9699282	·9699747	·9700213	·9700678	·9701143	·9701608	·9702074	·9702539	·9703004	465
934	·9703469	·9703934	·9704399	·9704863	·9705328	·9705793	·9706258	·9706722	·9707187	·9707652	465
935	·9708116	·9708581	·9709045	·9709509	·9709974	·9710438	·9710902	·9711366	·9711830	·9712294	464
936	·9712758	·9713222	·9713686	·9714150	·9714614	·9715078	·9715542	·9716005	·9716469	·9716932	464
937	·9717396	·9717859	·9718323	·9718786	·9719249	·9719713	·9720176	·9720639	·9721102	·9721565	463
938	·9722028	·9722491	·9722954	·9723417	·9723880	·9724343	·9724805	·9725268	·9725731	·9726193	463
939	·9726656	·9727118	·9727581	·9728043	·9728506	·9728968	·9729430	·9729892	·9730354	·9730816	462
940	·9731279	·9731741	·9732202	·9732664	·9733126	·9733588	·9734050	·9734511	·9734973	·9735435	462
941	·9735896	·9736358	·9736819	·9737281	·9737742	·9738203	·9738664	·9739126	·9739587	·9740048	461
942	·9740509	·9740970	·9741431	·9741892	·9742353	·9742814	·9743274	·9743735	·9744196	·9744656	461
943	·9745117	·9745577	·9746038	·9746498	·9746959	·9747419	·9747879	·9748340	·9748800	·9749260	460
914	·9749720	·9750180	·9750640	·9751100	·9751560	·9752020	·9752479	·9752939	·9753399	·9753858	460
945	·9754318	·9754778	·9755237	·9755697	·9756156	·9756615	·9757075	·9757534	·9757993	·9758452	459
946	·9758911	·9759370	·9759829	·9760288	·9760747	·9761206	·9761665	·9762124	·9762582	·9763041	459
947	·9763500	·9763958	·9764417	·9764875	·9765334	·9765792	·9766251	·9766709	·9767167	·9767625	458
948	·9768083	·9768541	·9769000	·9769458	·9769915	·9770373	·9770831	·9771289	·9771747	·9772204	458
949	·9772662	9773120	·9773577	·9774035	·9774492	·9774950	·9775407	·9775864	·9776322	·9776779	457

No.	0	1	2	3	4	5	6	7	8	9	Dif.
950	·9777236	·9777693	·9778150	·9778607	·9779064	·9779521	·9779978	·9780435	·9780892	·9781348	457
951	·9781805	·9782262	·9782718	·9783175	·9783631	·9784088	·9784544	·9785001	·9785457	·9785913	456
952	·9786369	·9786826	·9787282	·9787738	·9788194	·9788650	·9789106	·9789562	·9790017	·9790473	456
953	·9790929	·9791385	·9791840	·9792296	·9792751	·9793207	·9793662	·9794118	·9794573	·9795028	455
954	·9795484	·9795939	·9796394	·9796849	·9797304	·9797759	·9798214	·9798669	·9799124	·9799579	455
955	·9800034	·9800488	·9800943	·9801398	·9801852	·9802307	·9802761	·9803216	·9803670	·9804125	454
956	·9804579	·9805033	·9805487	·9805942	·9806396	·9806850	·9807304	·9807758	·9808212	·9808666	454
957	·9809119	·9809573	·9810027	·9810481	·9810934	·9811388	·9811841	·9812295	·9812748	·9813202	453
958	·9813655	·9814108	·9814562	·9815015	·9815468	·9815921	·9816374	·9816827	·9817280	·9817733	453
959	·9818186	·9818639	·9819092	·9819544	·9819997	·9820450	·9820902	·9821355	·9821807	·9822260	453
960	·9822712	·9823165	·9823617	·9824069	·9824522	·9824974	·9825426	·9825878	·9826330	·9826782	452
961	·9827234	·9827686	·9828138	·9828589	·9829041	·9829493	·9829945	·9830396	·9830848	·9831300	452
962	·9831751	·9832202	·9832654	·9833105	·9833556	·9834007	·9834459	·9834910	·9835361	·9835812	451
963	·9836263	·9836714	·9837165	·9837616	·9838066	·9838517	·9838968	·9839419	·9839869	·9840320	451
964	·9840770	·9841221	·9841671	·9842122	·9842572	·9843022	·9843473	·9843923	·9844373	·9844823	450
965	·9845273	·9845723	·9846173	·9846623	·9847073	·9847523	·9847973	·9848422	·9848872	·9849322	450
966	·9849771	·9850221	·9850670	·9851120	·9851569	·9852019	·9852468	·9852917	·9853366	·9853815	449
967	·9854265	·9854714	·9855163	·9855612	·9856061	·9856510	·9856959	·9857407	·9857856	·9858305	449
968	·9858754	·9859202	·9859651	·9860099	·9860548	·9860996	·9861445	·9861893	·9862341	·9862790	448
969	·9863238	·9863686	·9864134	·9864582	·9865030	·9865478	·9865926	·9866374	·9866822	·9867270	448
970	·9867717	·9868165	·9868613	·9869060	·9869508	·9869955	·9870403	·9870850	·9871298	·9871745	447
971	·9872192	·9872640	·9873087	·9873534	·9873981	·9874428	·9874875	·9875322	·9875769	·9876216	447
972	·9876663	·9877109	·9877556	·9878003	·9878450	·9878896	·9879343	·9879789	·9880236	·9880682	446
973	·9881128	·9881575	·9882021	·9882467	·9882913	·9883360	·9883806	·9884252	·9884698	·9885144	446
974	·9885590	·9886035	·9886481	·9886927	·9887373	·9887818	·9888264	·9888710	·9889155	·9889601	445
No.	0	1	2	3	4	5	6	7	8	9	Dif.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
975	·9890046	·9890492	·9890937	·9891382	·9891828	·9892273	·9892718	·9893163	·9893608	·9894053	445
976	·9894498	·9894943	·9895388	·9895833	·9896278	·9896722	·9897167	·9897612	·9898057	·9898501	444
977	·9898946	·9899390	·9899835	·9900279	·9900723	·9901168	·9901612	·9902056	·9902500	·9902944	444
978	·9903389	·9903833	·9904277	·9904721	·9905164	·9905608	·9906052	·9906496	·9906940	·9907383	444
979	·9907827	·9908271	·9908714	·9909158	·9909601	·9910044	·9910488	·9910931	·9911374	·9911818	443
980	·9912261	·9912704	·9913147	·9913590	·9914033	·9914476	·9914919	·9915362	·9915805	·9916247	443
981	·9916690	·9917133	·9917575	·9918018	·9918461	·9918903	·9919345	·9919788	·9920230	·9920673	442
982	·9921115	·9921557	·9921999	·9922441	·9922884	·9923326	·9923768	·9924210	·9924651	·9925093	442
983	·9925535	·9925977	·9926419	·9926860	·9927302	·9927744	·9928185	·9928627	·9929068	·9929510	441
984	·9929951	·9930392	·9930834	·9931275	·9931716	·9932157	·9932598	·9933039	·9933480	·9933921	441
985	·9934362	·9934803	·9935244	·9935685	·9936126	·9936566	·9937007	·9937448	·9937888	·9938329	441
986	·9938769	·9939210	·9939650	·9940090	·9940531	·9940971	·9941411	·9941851	·9942291	·9942731	440
987	·9943172	·9943612	·9944051	·9944491	·9944931	·9945371	·9945811	·9946251	·9946690	·9947130	440
988	·9947569	·9948009	·9948448	·9948888	·9949327	·9949767	·9950206	·9950645	·9951085	·9951524	439
989	·9951963	·9952402	·9952841	·9953280	·9953719	·9954158	·9954597	·9955036	·9955474	·9955913	439
990	·9956352	·9956791	·9957229	·9957668	·9958106	·9958545	·9958983	·9959422	·9959860	·9960298	438
991	·9960737	·9961175	·9961613	·9962051	·9962489	·9962927	·9963365	·9963803	·9964241	·9964679	438
992	·9965117	·9965554	·9965992	·9966430	·9966868	·9967305	·9967743	·9968180	·9968618	·9969055	438
993	·9969492	·9969930	·9970367	·9970804	·9971242	·9971679	·9972116	·9972553	·9972990	·9973427	437
994	·9973864	·9974301	·9974738	·9975174	·9975611	·9976048	·9976485	·9976921	·9977358	·9977794	437
995	·9978231	·9978667	·9979104	·9979540	·9979976	·9980413	·9980849	·9981285	·9981721	·9982157	436
996	·9982593	·9983029	·9983465	·9983901	·9984337	·9984773	·9985209	·9985645	·9986080	·9986516	436
997	·9986952	·9987387	·9987823	·9988258	·9988694	·9989129	·9989564	·9990000	·9990435	·9990870	435
998	·9991305	·9991741	·9992176	·9992611	·9993046	·9993481	·9993916	·9994350	·9994785	·9995220	435
999	·9995655	·9996090	·9996524	·9996959	·9997393	·9997828	·9998262	·9998697	·9999131	·9999566	435
No.	0	1	2	3	4	5	6	7	8	9	Diff.

TABLE OF HYPERBOLIC LOGARITHMS.

To find the hyperbolic logarithm of a number multiply the common logarithm of the number by the figures 2·302585052994, and the product is the hyperbolic logarithm of that number.

Example.—The common logarithm of 3·75 is ·5740313; the hyperbolic logarithm is then found by multiplying 2·302585 by ·5740313 = 1·3217559, the hyperbolic logarithm.

No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
1·01	·0099503	1·35	·3001046	1·69	·5247284	2·03	·7080357
1·02	·0198026	1·36	·3074847	1·70	·5306282	2·04	·7129497
1·03	·0295588	1·37	·3148108	1·71	·5364933	2·05	·7178399
1·04	·0392207	1·38	·3220833	1·72	·5423241	2·06	·7227058
1·05	·0487902	1·39	·3293037	1·73	·5481212	2·07	·7275485
1·06	·0582690	1·40	·3364721	1·74	·5538850	2·08	·7323678
1·07	·0676586	1·41	·3435895	1·75	·5596156	2·09	·7371640
1·08	·0769610	1·42	·3506568	1·76	·5653138	2·10	·7419373
1·09	·0861777	1·43	·3576744	1·77	·5709795	2·11	·7466880
1·10	·0953102	1·44	·3646431	1·78	·5766133	2·12	·7514160
1·11	·1043600	1·45	·3715635	1·79	·5822156	2·13	·7561219
1·12	·1133285	1·46	·3784365	1·80	·5877866	2·14	·7608058
1·13	·1222174	1·47	·3852623	1·81	·5933268	2·15	·7654680
1·14	·1310284	1·48	·3920420	1·82	·5988365	2·16	·7701082
1·15	·1397614	1·49	·3987762	1·83	·6043159	2·17	·7747271
1·16	·1484199	1·50	·4054652	1·84	·6097653	2·18	·7793248
1·17	·1570038	1·51	·4121094	1·85	·6151855	2·19	·7839014
1·18	·1655144	1·52	·4187103	1·86	·6205763	2·20	·7884573
1·19	·1739534	1·53	·4252675	1·87	·6259384	2·21	·7929925
1·20	·1823215	1·54	·4317823	1·88	·6312717	2·22	·7975071
1·21	·1906204	1·55	·4382550	1·89	·6365768	2·23	·8020015
1·22	·1988507	1·56	·4446858	1·90	·6418538	2·24	·8064758
1·23	·2070140	1·57	·4510756	1·91	·6471033	2·25	·8109303
1·24	·2151113	1·58	·4574247	1·92	·6523251	2·26	·8153647
1·25	·2231435	1·59	·4637339	1·93	·6575200	2·27	·8197798
1·26	·2311161	1·60	·4700036	1·94	·6626879	2·28	·8241754
1·27	·2390167	1·61	·4762341	1·95	·6678294	2·29	·8285518
1·28	·2468601	1·62	·4824260	1·96	·6729445	2·30	·8329089
1·29	·2546422	1·63	·4885801	1·97	·6780335	2·31	·8372474
1·30	·2623643	1·64	·4946959	1·98	·6830968	2·32	·8415671
1·31	·2700271	1·65	·5007752	1·99	·6881346	2·33	·8458682
1·32	·2776316	1·66	·5068176	2·00	·6931472	2·34	·8501509
1·33	·2851787	1·67	·5128237	2·01	·6981347	2·35	·8544154
1·34	·2926696	1·68	·5187938	2·02	·7030974	2·36	·8586616

No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
2·37	·8628899	2·85	1·0473189	3·33	1·2029722	3·81	1·3376291
2·38	·8671004	2·86	1·0508215	3·34	1·2059707	3·82	1·3402504
2·39	·8712933	2·87	1·0543120	3·35	1·2089603	3·83	1·3428648
2·40	·8754686	2·88	1·0577902	3·36	1·2119409	3·84	1·3454723
2·41	·8796266	2·89	1·0612564	3·37	1·2149127	3·85	1·3480731
2·42	·8837675	2·90	1·0647107	3·38	1·2178757	3·86	1·3506671
2·43	·8878912	2·91	1·0681529	3·39	1·2208299	3·87	1·3532544
2·44	·8919980	2·92	1·0715836	3·40	1·2237754	3·88	1·3558351
2·45	·8960879	2·93	1·0750024	3·41	1·2267122	3·89	1·3584091
2·46	·9001613	2·94	1·0784095	3·42	1·2296405	3·90	1·3609765
2·47	·9042181	2·95	1·0818051	3·43	1·2325605	3·91	1·3635373
2·48	·9082585	2·96	1·0851892	3·44	1·2354714	3·92	1·3660916
2·49	·9122826	2·97	1·0885619	3·45	1·2383742	3·93	1·3686395
2·50	·9162907	2·98	1·0919233	3·46	1·2412685	3·94	1·3711807
2·51	·9202825	2·99	1·0952733	3·47	1·2441545	3·95	1·3737156
2·52	·9242589	3·00	1·0986124	3·48	1·2470322	3·96	1·3762440
2·53	·9282193	3·01	1·1019400	3·49	1·2499017	3·97	1·3787661
2·54	·9321640	3·02	1·1052568	3·50	1·2527629	3·98	1·3812818
2·55	·9360934	3·03	1·1085626	3·51	1·2556160	3·99	1·3837911
2·56	·9400072	3·04	1·1118575	3·52	1·2584609	4·00	1·3862943
2·57	·9439058	3·05	1·1151415	3·53	1·2612978	4·01	1·3887912
2·58	·9477893	3·06	1·1184147	3·54	1·2641266	4·02	1·3912818
2·59	·9516578	3·07	1·1216775	3·55	1·2669475	4·03	1·3937763
2·60	·9555112	3·08	1·1249295	3·56	1·2697605	4·04	1·3962446
2·61	·9593502	3·09	1·1281710	3·57	1·2725655	4·05	1·3987168
2·62	·9631743	3·10	1·1314021	3·58	1·2753627	4·06	1·4011829
2·63	·9669838	3·11	1·1346227	3·59	1·2781521	4·07	1·4036429
2·64	·9707789	3·12	1·1378330	3·60	1·2809338	4·08	1·4060969
2·65	·9745596	3·13	1·1410330	3·61	1·2837077	4·09	1·4085449
2·66	·9783259	3·14	1·1442227	3·62	1·2864740	4·10	1·4109869
2·67	·9820784	3·15	1·1474024	3·63	1·2892326	4·11	1·4134230
2·68	·9858167	3·16	1·1505718	3·64	1·2919836	4·12	1·4158531
2·69	·9895411	3·17	1·1537315	3·65	1·2947271	4·13	1·4182774
2·70	·9932518	3·18	1·1568811	3·66	1·2974631	4·14	1·4206957
2·71	·9969486	3·19	1·1600209	3·67	1·3001916	4·15	1·4231083
2·72	1·0006318	3·20	1·1631508	3·68	1·3029127	4·16	1·4255150
2·73	1·0043015	3·21	1·1662708	3·69	1·3056264	4·17	1·4279161
2·74	1·0079579	3·22	1·1693813	3·70	1·3083328	4·18	1·4303112
2·75	1·0116009	3·23	1·1724821	3·71	1·3110318	4·19	1·4327007
2.76	1·0152806	3·24	1·1755733	3·72	1·3137236	4·20	1·4350844
2.77	1·0188473	3·25	1·1786549	3·73	1·3164082	4·21	1·4374626
2.78	1·0224509	3·26	1·1817271	3·74	1·3190856	4·22	1·4398351
2,79	1·0260415	3·27	1·1847899	3·75	1·3217559	4·23	1·4422020
2·80	1·0296193	3·28	1·1878434	3·76	1·3244189	4·24	1·4445632
2·81	1·0331843	3·29	1·1908875	3·77	1·3270749	4·25	1·4469189
2.82	1·0367368	3·30	1·1939224	3·78	1·3297240	4·26	1·4492691
2.83	1·0402766	3·31	1·1969481	3·79	1·3323660	4·27	1·4516138
2.84	1·0438040	3·32	1·1999647	3·80	1·3350010	4·28	1·4539530

o.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
29	1·4562867	4·77	1·5623462	5·25	1·6582280	5·73	1·7457155
30	1·4586149	4·78	1·5644405	5·26	1·6601310	5·74	1·7474591
31	1·4609379	4·79	1·5665304	5·27	1·6620303	5·75	1·7491998
32	1·4632553	4·80	1·5686159	5·28	1·6639260	5·76	1·7509374
33	1·4655675	4·81	1·5706971	5·29	1·6658182	5·77	1·7526720
34	1·4678743	4·82	1·5727739	5·30	1·6677068	5·78	1·7544036
35	1·4701758	4·83	1·5748464	5·31	1·6695918	5·79	1·7561323
36	1·4724720	4·84	1·5769147	5·32	1·6714733	5·80	1·7578579
37	1·4747630	4·85	1·5789787	5·33	1·6733512	5·81	1·7595805
38	1·4770487	4·86	1·5810384	5·34	1·6752256	5·82	1·7613002
39	1·4793292	4·87	1·5830939	5·35	1·6770965	5·83	1·7630170
40	1·4816045	4·88	1·5851452	5·36	1·6789639	5·84	1·7647308
41	1·4838746	4·89	1·5871923	5·37	1·6808278	5·85	1·7664416
42	1·4861396	4·90	1·5892352	5·38	1·6826882	5·86	1·7681496
43	1·4883994	4·91	1·5912739	5·39	1·6845453	5·87	1·7698546
44	1·4906543	4·92	1·5933085	5·40	1·6863989	5·88	1·7715567
45	1·4929040	4·93	1·5953389	5·41	1·6882491	5·89	1·7732559
46	1·4951487	4·94	1·5973653	5·42	1·6900958	5·90	1·7749523
47	1·4973883	4·95	1·5993875	5·43	1·6919391	5·91	1·7768458
48	1·4996230	4·96	1·6014057	5·44	1·6937790	5·92	1·7783364
49	1·5018527	4·97	1·6034198	5·45	1·6956155	5·93	1·7800242
50	1·5040773	4·98	1·6054298	5·46	1·6974487	5·94	1·7817091
51	1·5062971	4·99	1·6074358	5·47	1·6992786	5·95	1·7833912
·52	1·5085119	5·00	1·6094377	5·48	1·7011051	5·96	1·7850704
·53	1·5107219	5·01	1·6114359	5·49	1·7029282	5·97	1·7867469
·54	1·5129269	5·02	1·6134300	5·50	1·7047481	5·98	1·7884205
·55	1·5151272	5·03	1·6154200	5·51	1·7065646	5·99	1·7900914
·56	1·5173226	5·04	1·6174060	5·52	1·7083778	6·00	1·7917595
·57	1·5195132	5·05	1·6193882	5·53	1·7101878	6·01	1·7934247
·58	1·5216990	5·06	1·6213664	5·54	1·7119944	6·02	1·7950872
·59	1·5238800	5·07	1·6233408	5·55	1·7137979	6·03	1·7967470
·60	1·5260563	5·08	1·6253112	5·56	1·7155981	6·04	1·7984040
·61	1·5282278	5·09	1·6272778	5·57	1·7173950	6·05	1·8000582
·62	1·5303947	5·10	1·6292405	5·58	1·7191887	6·06	1·8017098
·63	1·5325568	5·11	1·6311994	5·59	1·7209792	6·07	1·8033586
·64	1·5347143	5·12	1·6331544	5·60	1·7227660	6·08	1·8050047
·65	1·5368672	5·13	1·6351057	5·61	1·7245507	6·09	1·8066481
·66	1·5390154	5·14	1·6370530	5·62	1·7263316	6·10	1·8082887
·67	1·5411590	5·15	1·6389967	5·63	1·7281094	6·11	1·8099267
·68	1·5432981	5·16	1·6409365	5·64	1·7298840	6·12	1·8115621
·69	1·5454325	5·17	1·6428726	5·65	1·7316555	6·13	1·8131947
·70	1·5475625	5·18	1·6448050	5·66	1·7334238	6·14	1·8148247
·71	1·5496879	5·19	1·6467336	5·67	1·7351891	6·15	1·8164520
·72	1·5518087	5·20	1·6486586	5·68	1·7369512	6·16	1·8180767
·73	1·5539252	5·21	1·6505798	5·69	1·7387102	6·17	1·8196988
·74	1·5560371	5·22	1·6524974	5·70	1·7404661	6·18	1·8213182
·75	1·5581446	5·23	1·6544112	5·71	1·7422189	6·19	1·8229351
·76	1·5602476	5·24	1·6563214	5·72	1·7439687	6·20	1·8245493

No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
6·21	1·8261608	6·69	1·9006138	7·17	1·9699056	7·65	2·034705
6·22	1·8277699	6·70	1·9021075	7·18	1·9712993	7·66	2·036011
6·23	1·8293763	6·71	1·9035989	7·19	1·9726911	7·67	2·037316
6·24	1·8309801	6·72	1·9050881	7·20	1·9740810	7·68	2·038619
6·25	1·8325814	6·73	1·9065751	7·21	1·9754689	7·69	2·039920
6·26	1·8341801	6·74	1·9080600	7·22	1·9768549	7·70	2·041220
6·27	1·8357763	6·75	1·9095425	7·23	1·9782390	7·71	2·042518
6·28	1·8373699	6·76	1·9110228	7·24	1·9796212	7·72	2·043814
6·29	1·8389610	6·77	1·9125011	7·25	1·9810014	7·73	2·045108
6·30	1·8405496	6·78	1·9139771	7·26	1·9823798	7·74	2·046401
6·31	1·8421356	6·79	1·9154509	7·27	1·9837562	7·75	2·047692
6·32	1·8437191	6·80	1·9169226	7·28	1·9851308	7·76	2·048982
6·33	1·8453002	6·81	1·9183921	7·29	1·9865035	7·77	2·050270
6·34	1·8468787	6·82	1·9198594	7·30	1·9878743	7·78	2·051556
6·35	1·8484547	6·83	1·9213247	7·31	1·9892432	7·79	2·052840
6·36	1·8500283	6·84	1·9227877	7·32	1·9906103	7·80	2·054123
6·37	1·8515994	6·85	1·9242486	7·33	1·9919754	7·81	2·055404
6·38	1·8531680	6·86	1·9257074	7·34	1·9933387	7·82	2·056684
6·39	1·8547342	6·87	1·9271641	7·35	1·9947002	7·83	2·057962
6·40	1·8562979	6·88	1·9286186	7·36	1·9960599	7·84	2·059238
6·41	1·8578592	6·89	1·9300710	7·37	1·9974177	7·85	2·060513
6·42	1·8594181	6·90	1·9315214	7·38	1·9987736	7·86	2·061786
6·43	1·8609745	6·91	1·9329696	7·39	2·0001278	7·87	2·063058
6·44	1·8625285	6·92	1·9344157	7·40	2·0014800	7·88	2·064327
6·45	1·8640801	6·93	1·9358598	7·41	2·0028305	7·89	2·065596
6·46	1·8656293	6·94	1·9373017	7·42	2·0041790	7·90	2·066862
6·47	1·8671761	6·95	1·9387416	7·43	2·0055258	7·91	2·068127
6·48	1·8687205	6·96	1·9401794	7·44	2·0068708	7·92	2·069391
6·49	1·8702625	6·97	1·9416152	7·45	2·0082140	7·93	2·070653
6·50	1·8718021	6·98	1·9430489	7·46	2·0095553	7·94	2·071913
6·51	1·8733394	6·99	1·9444805	7·47	2·0108949	7·95	2·073171
6·52	1·8748743	7·00	1·9459099	7·48	2·0122327	7·96	2·074429
6·53	1·8764069	7·01	1·9473376	7·49	2·0135687	7·97	2·075684
6·54	1·8779371	7·02	1·9487632	7·50	2·0149030	7·98	2·076938
6·55	1·8794650	7·03	1·9501866	7·51	2·0162354	7·99	2·078190
6·56	1·8809906	7·04	1·9516080	7·52	2·0175661	8·00	2·079441
6·57	1·8825138	7·05	1·9530275	7·53	2·0188950	8·01	2·080690
6·58	1·8840347	7·06	1·9544449	7·54	2·0202221	8·02	2·081938
6·59	1·8855533	7·07	1·9558604	7·55	2·0215475	8·03	2·083184
6·60	1·8870697	7·08	1·9572739	7·56	2·0228711	8·04	2·084429
6·61	1·8885837	7·09	1·9586853	7·57	2·0241929	8·05	2·085672
6·62	1·8900954	7·10	1·9600947	7·58	2·0255131	8·06	2·086913
6·63	1·8916048	7·11	1·9615022	7·59	2·0268315	8·07	2·088153
6·64	1·8931119	7·12	1·9629077	7·60	2·0281482	8·08	2·089391
6·65	1·8946168	7·13	1·9643112	7·61	2·0294631	8·09	2·090628
6·66	1·8961194	7·14	1·9657127	7·62	2·0307763	8·10	2·091864
6·67	1·8976198	7·15	1·9671123	7·63	2·0320878	8·11	2·093098
6·68	1·8991179	7·16	1·9685099	7·64	2·0333976	8·12	2·094330

No.	Logarithm	No.	Logarithm	No.	Logarithm	No.	Logarithm
8·13	2·0955613	8·61	2·1529243	9·09	2·2071748	9·57	2·2586332
8·14	2·0967905	8·62	2·1540851	9·10	2·2082744	9·58	2·2596776
8·15	2·0980182	8·63	2·1552445	9·11	2·2093727	9·59	2·2607209
8·16	2·0992444	8·64	2·1564026	9·12	2·2104697	9·60	2·2617631
8·17	2·1004691	8·65	2·1575593	9·13	2·2115656	9·61	2·2628042
8·18	2·1016923	8·66	2·1587147	9·14	2·2126603	9·62	2·2638442
8·19	2·1029140	8·67	2·1598687	9·15	2·2137538	9·63	2·2648832
8·20	2·1041341	8·68	2·1610215	9·16	2·2148462	9·64	2·2659211
8·21	2·1053529	8·69	2·1621729	9·17	2·2159372	9·65	2·2669579
8·22	2·1065702	8·70	2·1633230	9·18	2·2170272	9·66	2·2679936
8·23	2·1077861	8·71	2·1644718	9·19	2·2181160	9·67	2·2690282
8·24	2·1089998	8·72	2·1656192	9·20	2·2192034	9·68	2·2700618
8·25	2·1102128	8·73	2·1667653	9·21	2·2202898	9·69	2·2710944
8·26	2·1114243	8·74	2·1679101	9·22	2·2213750	9·70	2·2721258
8·27	2·1126343	8·75	2·1690536	9·23	2·2224590	9·71	2·2731562
8·28	2·1138428	8·76	2·1701959	9·24	2·2235418	9·72	2·2741856
8·29	2·1150499	8·77	2·1713367	9·25	2·2246235	9·73	2·2752138
8·30	2·1162555	8·78	2·1724763	9·26	2·2257040	9·74	2·2762411
8·31	2·1174596	8·79	2·1736146	9·27	2·2267833	9·75	2·2772673
8·32	2·1186622	8·80	2·1747517	9·28	2·2278615	9·76	2·2782924
8·33	2·1198634	8·81	2·1758874	9·29	2·2289385	9·77	2·2793165
8·34	2·1210632	8·82	2·1770218	9·30	2·2300144	9·78	2·2803395
8·35	2·1222615	8·83	2·1781550	9·31	2·2310890	9·79	2·2813614
8·36	2·1234584	8·84	2·1792868	9·32	2·2321626	9·80	2·2823823
8·37	2·1246539	8·85	2·1804174	9·33	2·2332350	9·81	2·2834022
8·38	2·1258479	8·86	2·1815467	9·34	2·2343062	9·82	2·2844211
8·39	2·1270405	8·87	2·1826747	9·35	2·2353763	9·83	2·2854389
8·40	2·1282317	8·88	2·1838015	9·36	2·2364452	9·84	2·2864556
8·41	2·1294214	8·89	2·1849270	9·37	2·2375130	9·85	2·2874714
8·42	2·1306098	8·90	2·1860512	9·38	2·2385786	9·86	2·2884861
8·43	2·1317967	8·91	2·1871742	9·39	2·2396452	9·87	2·2894998
8·44	2·1329822	8·92	2·1882959	9·40	2·2407096	9·88	2·2905124
8·45	2·1341664	8·93	2·1894163	9·41	2·2417729	9·89	2·2915241
8·46	2·1353491	8·94	2·1905355	9·42	2·2428350	9·90	2·2925347
8·47	2·1365304	8·95	2·1916535	9·43	2·2438960	9·91	2·2935443
8·48	2·1377104	8·96	2·1927702	9·44	2·2449559	9·92	2·2945529
8·49	2·1388889	8·97	2·1938856	9·45	2·2460147	9·93	2·2955604
8·50	2·1400661	8·98	2·1949998	9·46	2·2470723	9·94	2·2965670
8·51	2·1412419	8·99	2·1961128	9·47	2·2481288	9·95	2·2975725
8·52	2·1424163	9·00	2·1972245	9·48	2·2491843	9·96	2·2985770
8·53	2·1435893	9·01	2·1983350	9·49	2·2502386	9·97	2·2995806
8·54	2·1447609	9·02	2·1994443	9·50	2·2512917	9·98	2·3005831
8·55	2·1459312	9·03	2·2005523	9·51	2·2523438	9·99	2·3015846
8·56	2·1471001	9·04	2·2016591	9·52	2·2533948	10·00	2·3025851
8·57	2·1482676	9·05	2·2027647	9·53	2·2544446	11·00	2·3978952
8·58	2·1494339	9·06	2·2038691	9·54	2·2554934	12·00	2·4849065
8·59	2·1505987	9·07	2·2049722	9·55	2·2565411	15·00	2·7080502
8·60	2·1517622	9·08	2·2060741	9·56	2·2575877	20·00	2·9957322

Table of Natural Sines, Tangents, Secants, &c.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
0	·000000	Infinite	·000000	Infinite	1·000000	1·00000	90
¼	·004363	229·1839	·004363	229·1817	1·000010	·999991	¾
½	·008727	114·5930	·008727	114·5887	1·000038	·999962	½
¾	·013090	76·39655	·013091	76·39001	1·000086	·999914	¼
1	·017452	57·29869	·017455	57·28996	1·000152	·999848	89
¼	·021815	45·84026	·021820	45·82935	1·000238	·999762	¾
½	·026177	38·20155	·026186	38·18846	1·000343	·999657	½
¾	·030539	32·74554	·030553	32·73026	1·000467	·999534	¼
2	·034900	28·65371	·034921	28·63625	1·000610	·999391	88
¼	·039260	25·47134	·039290	25·45170	1·000772	·999229	¾
½	·043619	22·92559	·043661	22·90377	1·000953	·999048	½
¾	·047978	20·84283	·048033	20·81883	1·001153	·998848	¼
3	·052336	19·10732	·052408	19·08114	1·001372	·998630	87
¼	·056693	17·63893	·056784	17·61056	1·001611	·998392	¾
½	·061049	16·38041	·061163	16·34986	1·001869	·998135	½
¾	·065403	15·28979	·065544	15·25705	1·002146	·997859	¼
4	·069757	14·33559	·069927	14·30067	1·002442	·997564	86
¼	·074109	13·49373	·074313	13·45663	1·002757	·997250	¾
½	·078459	12·74550	·078702	12·70621	1·003092	·996917	½
¾	·082808	12·07610	·083094	12·03462	1·003446	·996566	¼
5	·087156	11·47371	·087489	11·43005	1·003820	·996195	85
¼	·091502	10·92877	·091887	10·88292	1·004213	·995805	¾
½	·095846	10·43343	·096289	10·38540	1·004625	·995396	½
¾	·100188	9·981229	·100695	9·931009	1·005057	·994969	¼
6	·104529	9·566772	·105104	9·514365	1·005508	·994522	84
¼	·108867	9·185531	·109518	9·130935	1·005979	·994056	¾
½	·113203	8·833672	·113936	8·776887	1·006470	·993572	½
¾	·117537	8·507930	·118358	8·448957	1·006980	·993069	¼
7	·121869	8·205509	·122785	8·144346	1·007510	·992546	83
¼	·126199	7·923995	·127216	7·860642	1·008060	·992005	¾
½	·130526	7·661298	·131653	7·595754	1·008629	·991445	½
¾	·134851	7·415596	·136094	7·347861	1·009218	·990866	¼
8	·139173	7·185297	·140541	7·115370	1·009828	·990268	82
¼	·143493	6·968999	·144993	6·896880	1·010457	·989651	¾
½	·147809	6·765469	·149451	6·691156	1·011106	·989016	½
¾	·152123	6·573611	·153915	6·497104	1·011776	·988362	¼
9	·156435	6·392453	·158384	6·313752	1·012465	·987688	81
¼	·160743	6·221128	·162860	6·140230	1·013175	·986996	¾
½	·165048	6·058858	·167343	5·975764	1·013905	·986286	½
¾	·169350	5·904948	·171831	5·819657	1·014656	·985556	¼
10	·173648	5·758771	·176327	5·671282	1·015427	·984808	80
¼	·177944	5·619760	·180830	5·530072	1·016218	·984041	¾
½	·182236	5·487404	·185339	5·395517	1·017030	·983255	79½
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
10¾	·186524	5·361239	·189856	5·267152	1·017863	·982450	¼
11	·190809	5·240843	·194380	5·144554	1·018717	·981627	79
¼	·195090	5·125831	·198912	5·027340	1·019591	·980785	¾
½	·199368	5·015852	·203452	4·915157	1·020487	·979925	½
¾	·203642	4·910584	·208000	4·807685	1·021403	·979046	¼
12	·207912	4·809734	·212557	4·704630	1·022341	·978148	78
¼	·212178	4·713031	·217121	4·605721	1·023299	·977231	¾
½	·216440	4·620226	·221695	4·510709	1·024280	·976296	½
¾	·220697	4·531090	·226277	4·419364	1·025281	·975342	¼
13	·224951	4·445412	·230868	4·331476	1·026304	·974370	77
¼	·229200	4·362994	·235469	4·246848	1·027349	·973379	¾
½	·233445	4·283658	·240079	4·165300	1·028415	·972370	½
¾	·237686	4·207233	·244698	4·086663	1·029503	·971342	¼
14	·241922	4·133566	·249328	4·010781	1·030614	·970296	76
¼	·246153	4·062509	·253968	3·937509	1·031746	·969231	¾
½	·250380	3·993929	·258618	3·866713	1·032900	·968148	½
¾	·254602	3·927700	·263278	3·798266	1·034077	·967046	¼
15	·258819	3·863703	·267949	3·732051	1·035276	·965926	75
¼	·263031	3·801830	·272631	3·667958	1·036498	·964787	¾
½	·267238	3·741978	·277325	3·605884	1·037742	·963631	½
¾	·271440	3·684049	·282029	3·545733	1·039009	·962455	¼
16	·275637	3·627955	·286745	3·487414	1·040299	·961262	74
¼	·279829	3·573611	·291473	3·430845	1·041613	·960050	¾
½	·284015	3·520937	·296214	3·375943	1·042949	·958820	½
¾	·288196	3·469858	·300966	3·322636	1·044309	·957571	¼
17	·292372	3·420304	·305731	3·270853	1·045692	·956305	73
¼	·296542	3·372208	·310508	3·220526	1·047099	·955020	¾
½	·300706	3·325510	·315299	3·171595	1·048529	·953717	½
¾	·304864	3·280148	·320103	3·123999	1·049984	·952396	¼
18	·309017	3·236068	·324920	3·077684	1·051462	·951057	72
¼	·313164	3·193217	·329751	3·032595	1·052965	·949699	¾
½	·317305	3·151545	·334595	2·988685	1·054492	·948324	½
¾	·321440	3·111006	·339454	2·945905	1·056044	·946930	¼
19	·325568	3·071554	·344328	2·904211	1·057621	·945519	71
¼	·329691	3·033146	·349216	2·863560	1·059222	·944089	¾
½	·333807	2·995744	·354119	2·823913	1·060849	·942642	½
¾	·337917	2·959309	·359037	2·785231	1·062501	·941176	¼
20	·342020	2·923804	·363970	2·747477	1·064178	·939693	70
¼	·346117	2·889196	·368920	2·710619	1·065881	·938191	¾
½	·350207	2·855451	·373885	2·674622	1·067609	·936672	½
¾	·354291	2·822538	·378866	2·639455	1·069364	·935135	¼
21	·358368	2·790428	·383864	2·605089	1·071145	·933580	69
¼	·362438	2·759092	·388879	2·571496	1·072952	·932008	¾
½	·366501	2·728504	·393911	2·538648	1·074786	·930418	½
¾	·370557	2·698637	·398960	2·506520	1·076647	·928810	¼
22	·374607	2·669467	·404026	2·475087	1·078535	·927184	68
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
22¼	·378649	2·640971	·409111	2·444326	1·080450	·925541	¾
½	·382683	2·613126	·414214	2·414214	1·082392	·923880	½
¾	·386711	2·585911	·419335	2·384729	1·084362	·922201	¼
23	·390731	2·559305	·424475	2·355852	1·086360	·920505	67
¼	·394744	2·533288	·429634	2·327563	1·088387	·918791	¾
½	·398749	2·507843	·434812	2·299843	1·090441	·917060	½
¾	·402747	2·482950	·440011	2·272673	1·092524	·915312	¼
24	·406737	2·458593	·445229	2·246037	1·094636	·913546	66
¼	·410719	2·434756	·450467	2·219918	1·096777	·911762	¾
½	·414693	2·411421	·455726	2·194300	1·098948	·909961	½
¾	·418660	2·388575	·461006	2·169168	1·101148	·908143	¼
25	·422618	2·366202	·466308	2·144507	1·103378	·906308	65
¼	·426569	2·344288	·471631	2·120303	1·105638	·904455	¾
½	·430511	2·322821	·476976	2·096544	1·107929	·902585	½
¾	·434445	2·301786	·482343	2·073215	1·110250	·900698	¼
26	·438371	2·281172	·487733	2·050304	1·112602	·898794	64
¼	·442289	2·260967	·493145	2·027799	1·114985	·896873	¾
½	·446198	2·241159	·498582	2·005690	1·117400	·894934	½
¾	·450098	2·221736	·504042	1·983964	1·119847	·892979	¼
27	·453991	2·202689	·509525	1·962611	1·122326	·891007	63
¼	·457874	2·184007	·515034	1·941620	1·124838	·889017	¾
½	·461749	2·165681	·520567	1·920982	1·127382	·887011	½
¾	·465615	2·147699	·526126	1·900687	1·129959	·884988	¼
28	·469472	2·130055	·531709	1·880727	1·132570	·882948	62
¼	·473320	2·112737	·537319	1·861091	1·135215	·880891	¾
½	·477159	2·095739	·542956	1·841771	1·137893	·878817	½
¾	·480989	2·079051	·548619	1·822759	1·140606	·876727	¼
29	·484810	2·062665	·554309	1·804048	1·143354	·874620	61
¼	·488621	2·046575	·560027	1·785629	1·146137	·872496	¾
½	·492424	2·030772	·565773	1·767494	1·148956	·870356	½
¾	·496217	2·015249	·571547	1·749637	1·151810	·868199	¼
30	·500000	2·000000	·577350	1·732051	1·154701	·866025	60
¼	·503774	1·985017	·583183	1·714728	1·157628	·863836	¾
½	·507538	1·970294	·589045	1·697663	1·160592	·861629	½
¾	·511293	1·955825	·594938	1·680849	1·163594	·859406	¼
31	·515038	1·941604	·600861	1·664280	1·166633	·857167	59
¼	·518773	1·927624	·606815	1·647949	1·169711	·854912	¾
½	·522499	1·913881	·612801	1·631852	1·172828	·852640	½
¾	·526214	1·900368	·618819	1·615982	1·175983	·850352	¼
32	·529919	1·887080	·624869	1·600335	1·179178	·848048	58
¼	·533615	1·874012	·630953	1·584904	1·182414	·845728	¾
½	·537300	1·861159	·637070	1·569686	1·185689	·843391	½
¾	·540975	1·848516	·643222	1·554674	1·189006	·841039	¼
33	·544639	1·836079	·649408	1·539865	1·192363	·838671	57
¼	·548293	1·823842	·655629	1·525254	1·195763	·836286	¾
½	·551937	1·811801	·661886	1·510835	1·199205	·833886	56½
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Dog.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
33¾	·555570	1·799952	·668179	1·496606	1·202690	·831470	¼
34	·559193	1·788292	·674509	1·482561	1·206218	·829038	56
¼	·562805	1·776815	·680876	1·468697	1·209790	·826590	¾
½	·566406	1·765517	·687281	1·455009	1·213406	·824126	½
¾	·569997	1·754396	·693725	1·441494	1·217068	·821647	¼
35	·573576	1·743447	·700208	1·428148	1·220775	·819152	55
¼	·577145	1·732666	·706730	1·414967	1·224527	·816642	¾
½	·580703	1·722051	·713293	1·401948	1·228327	·814116	½
¾	·584250	1·711597	·719897	1·389088	1·232174	·811574	¼
36	·587785	1·701302	·726543	1·376382	1·236068	·809017	54
¼	·591310	1·691161	·733230	1·363828	1·240011	·806445	¾
½	·594823	1·681173	·739961	1·351422	1·244003	·803857	½
¾	·598325	1·671334	·746735	1·339162	1·248044	·801254	¼
37	·601815	1·661640	·753554	1·327045	1·252136	·798636	53
¼	·605294	1·652090	·760418	1·315067	1·256278	·796002	¾
½	·608761	1·642680	·767327	1·303225	1·260472	·793353	½
¾	·612217	1·633407	·774283	1·291518	1·264719	·790690	¼
38	·615662	1·624269	·781286	1·279942	1·269018	·788011	52
¼	·619094	1·615264	·788336	1·268494	1·273371	·785317	¾
½	·622515	1·606388	·795436	1·257172	1·277779	·782608	½
¾	·625924	1·597639	·802585	1·245974	1·282241	·779885	¼
39	·629320	1·589016	·809784	1·234897	1·286760	·777146	51
¼	·632705	1·580515	·817034	1·223939	1·291335	·774393	¾
½	·636078	1·572134	·824336	1·213097	1·295967	·771625	½
¾	·639439	1·563871	·831691	1·202369	1·300658	·768842	¼
40	·642788	1·555724	·839100	1·191754	1·305407	·766044	50
¼	·646124	1·547691	·846563	1·181248	1·310217	·763233	¾
½	·649448	1·539769	·854081	1·170850	1·315087	·760406	½
¾	·652760	1·531957	·861655	1·160557	1·320019	·757565	¼
41	·656059	1·524253	·869287	1·150368	1·325013	·754710	49
¼	·659346	1·516655	·876977	1·140282	1·330071	·751840	¾
½	·662620	1·509161	·884725	1·130294	1·335192	·748956	½
¾	·665882	1·501768	·892534	1·120405	1·340380	·746057	¼
42	·669131	1·494477	·900404	1·110613	1·345633	·743145	48
¼	·672367	1·487283	·908336	1·009142	1·350953	·740218	¾
½	·675590	1·480187	·916331	1·091309	1·356342	·737277	½
¾	·678801	1·473186	·924391	1·081794	1·361800	·734323	¼
43	·681998	1·466279	·932515	1·072369	1·367328	·731354	47
¼	·685183	1·459464	·940706	1·063031	1·372927	·728371	¾
½	·688355	1·452740	·948965	1·053780	1·378599	·725374	½
¾	·691513	1·446104	·957292	1·044614	1·384344	·722364	¼
44	·694658	1·439557	·965689	1·035530	1·390164	·719340	46
¼	·697791	1·433095	·974157	1·026529	1·396059	·716302	¾
½	·700909	1·426718	·982697	1·017607	1·402032	·713250	½
¾	·704015	1·420425	·991311	1·008765	1·408083	·710185	¼
45	·707107	1·414214	1·00000	1·000000	1·414214	·707107	45
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Table of Logarithmic Sines, Tangents, Secants, &c.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
0	·000000	Infinite	·000000	Infinite	10·00000	10·00000	90
¼	7·63982	12·36018	7·63982	12·36018	10·00000	9·99999	¾
½	7·94084	12·05916	7·94086	12·05914	10·00002	9·99998	½
¾	8·11693	11·88307	8·11696	11·88304	10·00004	9·99996	¼
1	8·24186	11·75814	8·24192	11·75808	10·00007	9·99993	89
¼	8·33875	11·66125	8·33886	11·66114	10·00010	9·99990	¾
½	8·41792	11·58208	8·41807	11·58193	10·00015	9·99985	½
¾	8·48485	11·51515	8·48505	11·51495	10·00020	9·99980	¼
2	8·54282	11·45718	8·54308	11·45692	10·00026	9·99974	88
¼	8·59395	11·40605	8·59428	11·40572	10·00034	9·99967	¾
½	8·63968	11·36032	8·64009	11·35991	10·00041	9·99959	½
¾	8·68104	11·31896	8·68154	11·31846	10·00050	9·99950	¼
3	8·71880	11·28120	8·71940	11·28060	10·00060	9·99940	87
¼	8·75353	11·24647	8·75423	11·24577	10·00070	9·99930	¾
½	8·78568	11·21432	8·78649	11·21351	10·00081	9·99919	½
¾	8·81560	11·18440	8·81653	11·18347	10·00093	9·99907	¼
4	8·84358	11·15642	8·84464	11·15536	10·00106	9·99894	86
¼	8·86987	11·13013	8·87106	11·12894	10·00120	9·99880	¾
½	8·89464	11·10536	8·89598	11·10402	10·00134	9·99866	½
¾	8·91807	11·08193	8·91957	11·08043	10·00149	9·99851	¼
5	8·94030	11·05970	8·94195	11·05805	10·00166	9·99834	85
¼	8·96143	11·03857	8·96325	11·03675	10·00183	9·99817	¾
½	8·98157	11·01843	8·98358	11·01642	10·00200	9·99800	½
¾	9·00082	10·99918	9·00301	10·99699	10·00219	9·99781	¼
6	9·01923	10·98077	9·02162	10·97838	10·00239	9·99761	84
¼	9·03690	10·96310	9·03948	10·96052	10·00259	9·99741	¾
½	9·05386	10·94614	9·05666	10·94334	10·00280	9·99720	½
¾	9·07018	10·92982	9·07320	10·92680	10·00302	9·99698	¼
7	9·08589	10·91411	9·08914	10·91086	10·00325	9·99675	83
¼	9·10106	10·89894	9·10454	10·89546	10·00349	9·99651	¾
½	9·11570	10·88430	9·11943	10·88057	10·00373	9·99627	½
¾	9·12985	10·87015	9·13384	10·86616	10·00399	9·99601	¼
8	9·14356	10·85644	9·14780	10·85220	10·00425	9·99575	82
¼	9·15683	10·84317	9·16135	10·83865	10·00452	9·99548	¾
½	9·16970	10·83030	9·17450	10·82550	10·00480	9·99520	½
¾	9·18220	10·81780	9·18728	10·81272	10·00508	9·99492	¼
9	9·19433	10·80567	9·19971	10·80029	10·00538	9·99462	81
¼	9·20613	10·79387	9·21182	10·78818	10·00568	9·99432	¾
½	9·21761	10·78239	9·22361	10·77639	10·00600	9·99400	½
¾	9·22878	10·77122	9·23510	10·76490	10·00632	9·99368	¼
10	9·23967	10·76033	9·24632	10·75368	10·00665	9·99335	80
¼	9·25028	10·74972	9·25727	10·74273	10·00699	9·99301	¾
½	9·26063	10·73937	9·26797	10·73203	10·00733	9·99267	79½
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
10¾	9·27073	10·72927	9·27842	10·72158	10·00769	9·99231	¼
11	9·28060	10·71940	9·28865	10·71135	10·00805	9·99195	79
¼	9·29024	10·70976	9·29866	10·70134	10·00843	9·99157	¾
½	9·29966	10·70034	9·30846	10·69154	10·00881	9·99119	½
¾	9·30887	10·69113	9·31806	10·68194	10·00920	9·99080	¼
12	9·31788	10·68212	9·32747	10·67253	10·00960	9·99040	78
¼	9·32670	10·67330	9·33670	10·66330	10·01000	9·99000	¾
½	9·33534	10·66466	9·34576	10·65424	10·01042	9·98958	½
¾	9·34380	10·65620	9·35464	10·64536	10·01084	9·98916	¼
13	9·35209	10·64791	9·36336	10·63664	10·01128	9·98872	77
¼	9·36022	10·63978	9·37193	10·62807	10·01172	9·98828	¾
½	9·36819	10·63181	9·38035	10·61965	10·01217	9·98783	½
¾	9·37600	10·62400	9·38863	10·61137	10·01263	9·98737	¼
14	9·38368	10·61632	9·39677	10·60323	10·01310	9·98690	76
¼	9·39121	10·60879	9·40478	10·59522	10·01357	9·98643	¾
½	9·39860	10·60140	9·41266	10·58734	10·01406	9·98594	½
¾	9·40586	10·59414	9·42041	10·57959	10·01455	9·98545	¼
15	9·41300	10·58700	9·42805	10·57195	10·01506	9·98494	75
¼	9·42001	10·57999	9·43558	10·56442	10·01557	9·98443	¾
½	9·42690	10·57310	9·44299	10·55701	10·01609	9·98391	½
¾	9·43367	10·56633	9·45029	10·54971	10·01662	9·98338	¼
16	9·44034	10·55966	9·45750	10·54250	10·01716	9·98284	74
¼	9·44689	10·55311	9·46460	10·53540	10·01771	9·98229	¾
½	9·45334	10·54666	9·47160	10·52840	10·01826	9·98174	½
¾	9·45969	10·54031	9·47852	10·52148	10·01883	9·98117	¼
17	9·46594	10·53406	9·48534	10·51466	10·01940	9·98060	73
¼	9·47209	10·52791	9·49207	10·50793	10·01999	9·98001	¾
½	9·47814	10·52186	9·49872	10·50128	10·02058	9·97942	½
¾	9·48411	10·51589	9·50529	10·49471	10·02118	9·97882	¼
18	9·48998	10·51002	9·51178	10·48822	10·02179	9·97821	72
¼	9·49577	10·50423	9·51819	10·48181	10·02241	9·97759	¾
½	9·50148	10·49852	9·52452	10·47548	10·02304	9·97696	½
¾	9·50710	10·49290	9·53078	10·46922	10·02368	9·97632	¼
19	9·51264	10·48736	9·53697	10·46303	10·02433	9·97567	71
¼	9·51811	10·48189	9·54309	10·45691	10·02499	9·97501	¾
½	9·52350	10·47650	9·54915	10·45085	10·02565	9·97435	½
¾	9·52881	10·47119	9·55514	10·44486	10·02633	9·97367	¼
20	9·53405	10·46595	9·56107	10·43893	10·02701	9·97299	70
¼	9·53922	10·46078	9·56693	10·43307	10·02771	9·97229	¾
½	9·54433	10·45567	9·57274	10·42726	10·02841	9·97159	½
¾	9·54936	10·45064	9·57849	10·42151	10·02913	9·97087	¼
21	9·55433	10·44567	9·58418	10·41582	10·02985	9·97015	69
¼	9·55923	10·44077	9·58981	10·41019	10·03058	9·96942	¾
½	9·56408	10·43592	9·59540	10·40460	10·03132	9·96868	½
¾	9·56886	10·43114	9·60093	10·39907	10·03207	9·96793	¼
22	9·57358	10·42642	9·60641	10·39359	10·03283	9·96717	68
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
22¼	9·57824	10·42176	9·61184	10·38816	10·03360	9·96640	¾
½	9·58284	10·41716	9·61722	10·38278	10·03438	9·96562	½
¾	9·58739	10·41261	9·62256	10·37744	10·03517	9·96483	¼
23	9·59188	10·40812	9·62785	10·37215	10·03597	9·96403	67
¼	9·59632	10·40368	9·63310	10·36690	10·03678	9·96322	¾
½	9·60070	10·39930	9·63830	10·36170	10·03760	9·96240	½
¾	9·60503	10·39497	9·64346	10·35654	10·03843	9·96157	¼
24	9·60931	10·39069	9·64858	10·35142	10·03927	9·96073	66
¼	9·61354	10·38646	9·65366	10·34634	10·04012	9·95988	¾
½	9·61773	10·38227	9·65870	10·34130	10·04098	9·95902	½
¾	9·62186	10·37814	9·66371	10·33629	10·04185	9·95815	¼
25	9·62595	10·37405	9·66867	10·33133	10·04272	9·95728	65
¼	9·62999	10·37001	9·67360	10·32640	10·04361	9·95639	¾
½	9·63398	10·36602	9·67850	10·32150	10·04451	9·95549	½
¾	9·63794	10·36206	9·68336	10·31664	10·04542	9·95458	¼
26	9·64184	10·35816	9·68818	10·31182	10·04634	9·95366	64
¼	9·64571	10·35429	9·69298	10·30703	10·04727	9·95273	¾
½	9·64953	10·35047	9·69774	10·30226	10·04821	9·95179	½
¾	9·65331	10·34669	9·70247	10·29753	10·04916	9·95084	¼
27	9·65705	10·34295	9·70717	10·29283	10·05012	9·94988	63
¼	9·66075	10·33925	9·71184	10·28816	10·05109	9·94891	¾
½	9·66441	10·33559	9·71648	10·28352	10·05207	9·94793	½
¾	9·66803	10·33197	9·72109	10·27891	10·05306	9·94694	¼
28	9·67161	10·32839	9·72567	10·27433	10·05407	9·94593	62
¼	9·67515	10·32485	9·73023	10·26977	10·05508	9·94492	¾
½	9·67866	10·32134	9·73476	10·26524	10·05610	9·94390	½
¾	9·68213	10·31787	9·73927	10·26073	10·05714	9·94286	¼
29	9·68557	10·31443	9·74375	10·25625	10·05818	9·94182	61
¼	9·68897	10·31103	9·74821	10·25179	10·05924	9·94076	¾
½	9·69234	10·30766	9·75264	10·24736	10·06030	9·93970	½
¾	9·69567	10·30433	9·75705	10·24295	10·06138	9·93862	¼
30	9·69897	10·30103	9·76144	10·23856	10·06247	9·93753	60
¼	9·70224	10·29776	9·76580	10·23420	10·06357	9·93643	¾
½	9·70547	10·29453	9·77015	10·22985	10·06468	9·93532	½
¾	9·70867	10·29133	9·77447	10·22553	10·06580	9·93420	¼
31	9·71184	10·28816	9·77877	10·22123	10·06693	9·93307	59
¼	9·71498	10·28502	9·78306	10·21694	10·06808	9·93192	¾
½	9·71809	10·28191	9·78732	10·21268	10·06923	9·93077	½
¾	9·72116	10·27884	9·79156	10·20844	10·07040	9·92960	¼
32	9·72421	10·27579	9·79579	10·20421	10·07158	9·92842	58
¼	9·72723	10·27277	9·80000	10·20000	10·07277	9·92723	¾
½	9·73022	10·26978	9·80419	10·19581	10·07397	9·92603	½
¾	9·73318	10·26682	9·80836	10·19164	10·07518	9·92482	¼
33	9·73611	10·26389	9·81252	10·18748	10·07641	9·92359	57
¼	9·73901	10·26099	9·81666	10·18334	10·07765	9·92235	¾
½	9·74189	10·25811	9·82078	10·17922	10·07889	9·92111	56½
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

Deg.	Sine	Cosecant	Tangent	Cotangent	Secant	Cosine	Deg.
33¾	9·74474	10·25526	9·82489	10·17511	10·08015	9·91985	¼
34	9·74756	10·25244	9·82899	10·17101	10·08143	9·91857	56
¼	9·75036	10·24964	9·83307	10·16693	10·08271	9·91729	¾
½	9·75313	10·24687	9·83713	10·16287	10·08401	9·91599	½
¾	9·75587	10·24413	9·84119	10·15881	10·08531	9·91469	¼
35	9·75859	10·24141	9·84523	10·15477	10·08664	9·91336	55
¼	9·76129	10·23871	9·84925	10·15075	10·08797	9·91203	¾
½	9·76395	10·23605	9·85327	10·14673	10·08931	9·91069	½
¾	9·76660	10·23340	9·85727	10·14273	10·09067	9·90933	¼
36	9·76922	10·23078	9·86126	10·13874	10·09204	9·90796	54
¼	9·77182	10·22819	9·86524	10·13476	10·09343	9·90657	¾
½	9·77439	10·22561	9·86921	10·13079	10·09482	9·90518	½
¾	9·77694	10·22306	9·87317	10·12683	10·09623	9·90377	¼
37	9·77946	10·22054	9·87711	10·12289	10·09765	9·90235	53
¼	9·78197	10·21803	9·88105	10·11895	10·09909	9·90091	¾
½	9·78445	10·21555	9·88498	10·11502	10·10053	9·89947	½
¾	9·78691	10·21309	9·88890	10·11110	10·10199	9·89801	¼
38	9·78934	10·21066	9·89281	10·10719	10·10347	9·89653	52
¼	9·79176	10·20824	9·89671	10·10329	10·10496	9·89505	¾
½	9·79415	10·20585	9·90061	10·09939	10·10646	9·89354	½
¾	9·79652	10·20348	9·90449	10·09551	10·10797	9·89203	¼
39	9·79887	10·20113	9·90837	10·09163	10·10950	9·89050	51
¼	9·80120	10·19880	9·91224	10·08776	10·11104	9·88896	¾
½	9·80351	10·19649	9·91610	10·08390	10·11259	9·88741	½
¾	9·80580	10·19420	9·91996	10·08003	10·11416	9·88584	¼
40	9·80807	10·19193	9·92381	10·07619	10·11575	9·88425	50
¼	9·81032	10·18968	9·92766	10·07234	10·11734	9·88266	¾
½	9·81254	10·18746	9·93150	10·06850	10·11895	9·88105	½
¾	9·81475	10·18525	9·93533	10·06467	10·12058	9·87942	¼
41	9·81694	10·18306	9·93916	10·06084	10·12222	9·87778	49
¼	9·81911	10·18089	9·94299	10·05701	10·12387	9·87613	¾
½	9·82126	10·17874	9·94681	10·05319	10·12554	9·87446	½
¾	9·82340	10·17660	9·95062	10·04938	10·12723	9·87277	¼
42	9·82551	10·17449	9·95444	10·04556	10·12893	9·87107	48
¼	9·82761	10·17239	9·95825	10·04175	10·13064	9·86936	¾
½	9·82968	10·17032	9·96205	10·03795	10·13237	9·86763	½
¾	9·83174	10·16826	9·96586	10·03414	10·13411	9·86589	¼
43	9·83378	10·16622	9·96966	10·03034	10·13587	9·86413	47
¼	9·83581	10·16419	9·97345	10·02655	10·13765	9·86235	¾
½	9·83781	10·16219	9·97725	10·02275	10·13944	9·86056	½
¾	9·83980	10·16020	9·98104	10·01896	10·14124	9·85876	¼
44	9·84177	10·15823	9·98484	10·01516	10·14307	9·85693	46
¼	9·84373	10·15628	9·98863	10·01137	10·14490	9·85510	¾
½	9·84566	10·15434	9·99242	10·00758	10·14676	9·85324	½
¾	9·84758	10·15242	9·99621	10·00379	10·14863	9·85137	¼
45	9·84949	10·15052	10·00000	10·00000	10·15052	9·84949	45
Deg.	Cosine	Secant	Cotangent	Tangent	Cosecant	Sine	Deg.

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